

(12) STANDARD PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 2019291194 B2**

(54) Title
Double-layer multi-strand cord with improved penetrability

(51) International Patent Classification(s)
D07B 1/06 (2006.01)

(21) Application No: **2019291194** (22) Date of Filing: **2019.06.04**

(87) WIPO No: **WO19/243691**

(30) Priority Data

(31)	Number	(32)	Date	(33)	Country
	1855458		2018.06.20		FR

(43) Publication Date: **2019.12.26**

(44) Accepted Journal Date: **2025.05.22**

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(56) Related Art
WO 2011/000950 A2
JP 2008255509 A
JP 2006291419 A
ANONYMOUS: "High tensile strength steel cord constructions for tyres",
RESEARCH DISCLOSURE, KENNETH MASON PUBLICATIONS, HAMPSHIRE, UK,
GB, vol. 340, no. 54, 1 August 1992 (1992-08-01), XP007118007, ISSN: 0374-4353
WO 2018/115728 A1
WO 2014/090996 A2



(51) Classification internationale des brevets :
D07B 1/06 (2006.01)

(21) Numéro de la demande internationale :
PCT/FR2019/051313

(22) Date de dépôt international :
04 juin 2019 (04.06.2019)

(25) Langue de dépôt : français

(26) Langue de publication : français

(30) Données relatives à la priorité :
1855458 20 juin 2018 (20.06.2018) FR

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(54) Title: DOUBLE-LAYER MULTI-STRAND CORD WITH IMPROVED PENETRABILITY

(54) Titre : CÂBLE MULTI-TORONS À DEUX COUCHES À PÉNÉTRABILITÉ AMÉLIORÉE

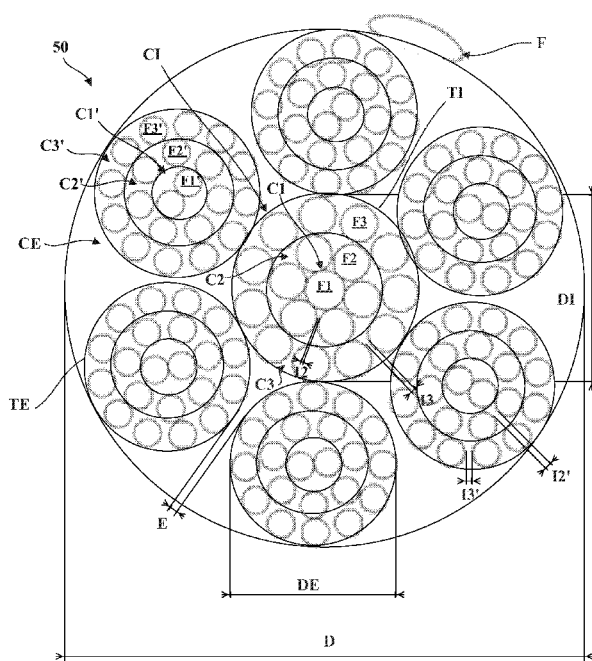


FIG. 3

(57) Abstract: The disclosed cord (50) comprises an inner strand (TI) and $L > 1$ outer strands (TE). Each outer strand (TE) comprises: - an inner layer (C1') consisting of $Q' = 2, 3$ or 4 inner wires (F1'); - an intermediate layer (C2') consisting of M' intermediate wires (F2') wound at a pitch $p2'$; - an outer layer (C3') consisting of N' outer wires (F3') wound at a pitch $p3'$. The outer layer (CE) of the cord is wound in a winding direction of the cord (50). Each outer layer (C3, C3') of each inner and outer strand (TI, TE) is wound in a same winding direction extending opposite the winding direction of the cord (50). The outer layer (CE) of the cord (50) is desaturated. The intermediate layer (C2') of each outer strand (TE) is desaturated, and the outer layer (C3') of each outer strand (TE) is desaturated. The following applies to pitches $p2'$ and $p3'$: $0.33 \leq (p3' - p2')/p3' \leq 0.45$ if $Q' = 2$; $0.35 \leq (p3' - p2')/p3' \leq 0.42$ if $Q' = 3$; $0.28 \leq (p3' - p2')/p3' \leq 0.43$ if $Q' = 4$.

(57) Abrégé : Le câble (50) comprend un toron interne (TI) et $L > 1$ torons externes (TE). Chaque toron externe (TE) comprend: - une couche interne (C1') de $Q' = 2, 3$ ou 4 fils internes (F1'), - une couche intermédiaire (C2') de M' fils intermédiaires (F2') enroulés au pas $p2'$, - une couche externe (C3') de N' fils externes (F3') enroulés au pas $p3'$. La couche externe (CE) du câble est enroulée selon un sens d'enroulement du câble (50). Chaque couche externe (C3, C3') de chaque toron interne et externe (TI, TE) est enroulée selon un même sens d'enroulement opposé au sens d'enroulement du câble (50). La couche externe (CE) du câble (50) est désaturée. La couche intermédiaire (C2') de chaque toron externe (TE) est désaturée et la couche externe (C3') de chaque toron externe (TE) est désaturée. Les pas $p2'$ et $p3'$ vérifient: $-0,33 \leq (p3' - p2')/p3' \leq 0,45$ dans le cas où $Q' = 2$, $-0,35 \leq (p3' - p2')/p3' \leq 0,42$ dans le cas où $Q' = 3$, $-0,28 \leq (p3' - p2')/p3' \leq 0,43$ dans le cas où $Q' = 4$.

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(81) **États désignés** (*sauf indication contraire, pour tout titre de protection nationale disponible*) : AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **États désignés** (*sauf indication contraire, pour tout titre de protection régionale disponible*) : ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), eurasien (AM, AZ, BY, KG, KZ, RU, TJ, TM), européen (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Publiée:

— avec rapport de recherche internationale (Art. 21(3))

Double-layer multi-strand cord with improved penetrability**Technical Field**

[001] The invention relates to multi-strand cords that can be used notably for reinforcing tyres, particularly tyres for heavy industrial vehicles.

Background Art

[002] A tyre having a radial carcass reinforcement comprises a tread, two inextensible beads, two sidewalls connecting the beads to the tread and a belt, or crown reinforcement, arranged circumferentially between the carcass reinforcement and the tread. The carcass reinforcement and the crown reinforcement comprise a plurality of plies made of elastomer compound, possibly reinforced with reinforcing elements such as cords or monofilaments, of the metal or textile type.

[003] The carcass reinforcement is anchored in each bead and surmounted radially by the crown reinforcement. The carcass reinforcement comprises a single carcass ply comprising carcass reinforcing metal filamentary elements. Each carcass reinforcing metal filamentary element makes an angle of between 80° and 90° with the circumferential direction of the tyre.

[004] The crown reinforcement generally comprises at least two superposed crown plies, sometimes referred to as working plies or crossed plies, the, generally metal, reinforcing elements of which are placed virtually parallel to one another within a ply but crossed from one ply to the other, that is to say inclined, symmetrically or asymmetrically, with respect to the median circumferential plane, by an angle which is generally comprised between 10° and 45°. The working plies generally comprise reinforcing elements that exhibit very low elongation so as to perform their function of guiding the tyre.

[005] The crown reinforcement may also comprise various other auxiliary plies or layers of elastomer compound, with widths that may vary as the case may be, and which may or may not contain reinforcing elements. Mention may be made by way of example of what are known as protective plies which have the role of protecting the remainder of the belt from external attack or perforations, or also of what are known as hooping plies which contain reinforcing elements that are oriented substantially in the circumferential direction (what are known as "zero-degree" plies), whether these be radially on the outside or on the inside with respect to the working plies. The protective plies generally comprise reinforcing elements that exhibit a high elongation so that they deform under the effect of a stress applied by an indenter, for example a rock.

[006] A reinforcing element for the plies described hereinabove and comprising a two-layer multi-strand metal cord as disclosed in the examples of WO2011064065,

WO2016202622 and WO2009048054 is known from the prior art. These cords comprise an internal layer of the cord made up of an internal strand and an external layer of the cord made up of six external strands wound in a helix around the internal layer of the cord.

[007] Each internal and external strand comprises an internal layer of the strand which layer is made up of two, three or four internal threads, an intermediate layer made up of 7 to 9 intermediate threads and an external layer made up of twelve to fifteen external threads. The intermediate and external layers of the internal strand are wound in the Z-direction around the internal and intermediate layers of the internal strand respectively. The intermediate and external layers of each external strand are wound in the Z-direction around the internal and intermediate layers of each external strand respectively. The external strands are wound in a helix around the internal strand in a direction of winding up the cord, this being the S-direction.

[008] A tyre of a heavy industrial vehicle, notably of construction plant type, is subjected to numerous attacks. Specifically, this type of tyre usually runs on an uneven road surface, sometimes resulting in perforations of the tread. These perforations allow the entry of corrosive agents, for example air and water, which oxidize the metal reinforcing elements of the various reinforcements, in particular of the crown plies, and considerably reduce the life of the tyre.

[009] One solution for increasing the life of the tyre is to combat the spread of these corrosive agents. Provision may thus be made to cover each internal and intermediate layer with an elastomer compound during the manufacture of the cord. During this process, the elastomer compound present penetrates the capillaries that are present between each layer of each strand and thus prevents the corrosive agents from spreading. Such cords, generally referred to as cords rubberized in situ, are well known from the prior art.

[010] Another solution for increasing the life of the tyre is to increase the cord's force at break. In general, the force at break is increased by increasing the diameter of the threads that make up the cord and/or by increasing the number of threads and/or the individual strength of each thread. However, increasing the diameter of the threads still further, for example beyond 0.50 mm, of necessity leads to a lowering of the flexibility of the cord, and this is not desirable. Increasing the number of threads usually leads to a lowering of the ability of the elastomer compound to penetrate the strands. Finally, increasing the individual strength of each thread entails significant investment in the installations used to manufacture the threads.

[011] It may be seen as desirable to provide a cord exhibiting improved penetrability of its external strands and better accessibility by the elastomer compound to the internal

strand as compared with the cord of the prior art, thus making it possible to reduce the ingress and spread of corrosive agents into and along the cord.

Summary

[012] CORD ACCORDING TO THE INVENTION

To this end, one subject of the invention is a two-layer multi-strand cord comprising:

– an internal layer of the cord made up of an internal strand having at least two layers comprising:

- an internal layer made up of Q internal thread(s) and
- an external layer made up of N external threads wound around the internal layer,

– an external layer of the cord made up of $L > 1$ external strands having three layers comprising:

- an internal layer made up of $Q' = 2, 3$ or 4 internal threads wound with a pitch $p1'$, the internal layer being wound in an internal-layer direction of each external strand,
- an intermediate layer made up of M' intermediate threads, wound around the internal layer with a pitch $p2'$, the intermediate layer being wound in an intermediate-layer direction of each external strand, and
- an external layer made up of N' external threads wound around the intermediate layer with a pitch $p3'$,

wherein:

- $p1'$ is different from $p2'$ and/or the internal-layer direction of each external strand is different from the intermediate-layer direction of each external strand;
- the external layer of the cord is wound around the internal layer of the cord in a direction of winding of the cord;
- each external layer of each internal and external strand is wound respectively around the internal and intermediate layer of each internal and external strand respectively in the same direction of winding that is the opposite to the direction of winding of the cord;
- the external layer (CE) of the cord is desaturated;
- the intermediate layer (C2') of each external strand (TE) is desaturated;
- the external layer (C3') of each external strand (TE) is desaturated; and
- the pitches $p2'$ and $p3'$ satisfy the relationship:
 - $0.36 \leq (p3' - p2')/p3' \leq 0.45$ in instances in which $Q' = 2$,
 - $0.36 \leq (p3' - p2')/p3' \leq 0.42$ in instances in which $Q' = 3$,
 - $0.36 \leq (p3' - p2')/p3' \leq 0.43$ in instances in which $Q' = 4$,

wherein the inter-thread distance of the intermediate layer of the external strand is greater than or equal to 35 μm .

[013] It will be recalled that, as is known, the pitch of a strand represents the length of this strand, measured parallel to the axis of the cord, after which the strand that has this pitch has made a complete turn around the said axis of the cord. Similarly, the pitch of a thread represents the length of this thread, measured parallel to the axis of the strand in which it is located, after which the thread that has this pitch has made a complete turn around the said axis of the strand.

[014] What is meant by the direction of winding of a layer of strands or of threads is the direction that the strands or the threads form with respect to the axis of the cord or of the strand. The direction of winding is commonly designated by the letter Z or S.

[015] The pitches, directions of winding, and diameters of the threads and of the strands are determined in accordance with standard ASTM D2969-04 of 2014.

[016] By definition, a desaturated layer of strands is one such that there is enough space left between the strands to allow an elastomer compound to pass. An external layer of strands that is desaturated means that the external strands do not touch and that there is enough space between two adjacent external strands to allow an elastomer composition to pass as far as the internal strands. By contrast, a layer of strands that is saturated is such that there is not enough space between the strands of the layer to allow an elastomer composition, to pass, for example because each pair of two strands of the layer touch one another.

[017] Advantageously, the inter-strand distance of the external layer of external strands, defined, on a cross section of the cord perpendicular to the main axis of the cord, as being the shortest distance separating, on average, the circular envelopes in which two adjacent external strands are inscribed, is greater than or equal to 30 μm . As a preference, the mean inter-strand distance E separating two adjacent external strands is greater than or equal to 70 μm , more preferably than/to 100 μm , more preferably still, than/to 150 μm , highly preferably, than/to 200 μm .

[018] What is meant by “at least two layers” is that the internal strand may, in certain embodiments, comprise two layers, which means to say that it comprises only two layers, but does not comprise just one or three of them; and that, in other embodiments, the internal strand may comprise three layers, which means to say that it comprises only three layers, but does not comprise just two or four of them.

[019] In the invention, the cord has two layers of strands, which means to say that it comprises an assembly made up of two layers of strands, neither more nor less, which means to say that the assembly has two layers of strands, not one, not three, but only two. The external layer of the cord is wound around the internal layer of the cord in

contact with the internal layer of the cord.

[020] The cord according to the invention has improved penetrability in comparison with a cord in which the ratio $(p3'-p2')/p3'$ is outside of the range of ratios according to the invention, such as for example the cord in the examples of WO2011064065, WO2016202622 and WO2009048054, and of which the penetrability can be improved by virtue of the invention. The inventors instigating the invention postulate the hypothesis that this ratio makes it possible to obtain relatively large radial windows for the passage of the elastomer compound within each external strand. The radial passage windows are defined as being the intersection between, on the one hand, the space projected onto a plane parallel to the main axis of the cord between two adjacent threads of the external layer of an external strand and, on the other hand, the space projected onto a plane parallel to the main axis of the cord between two adjacent threads of the intermediate layer of this external strand. Such a radial passage window is illustrated in Figure 24.

[021] In addition, by virtue of the fact that the external layer of the cord is desaturated, the cord according to the invention has spaces between the external strands that allow the elastomer compound to pass. Cords having a relatively high force at break because the external layer of the cord is saturated (because the external strands are in contact with one another in pairs), thereby forming an arch that absorbs the tensile forces applied to the cord, are known from the prior art. In the cord according to the invention, although the arch around the internal strand is broken, the high penetrability of the external strands rendered possible by the ratio $(p3'-p2')/p3'$ and the desaturated nature of the external layer of the cord allows the elastomer compound to penetrate, on the one hand, between the external strands and, on the other hand, between the external strands and the internal strand. In this way, the arch is at least partially restored and the drop in force at break of the cord is therefore limited while at the same time giving the cord its excellent penetrability. Furthermore, this feature allows the elastomer compound to infiltrate between the external layers of the internal and external strands so as to create a cushion of elastomer compound that at least partially absorbs the radial component of the force between the internal and external strands.

[022] According to the invention, the direction of winding of the cord that is the opposite to the directions of winding of each external layer of each internal and external strand gives the cord better penetrability, notably between the external strands. The inventors postulate the hypothesis that, by virtue of these directions of winding, the external threads of the external strands cross the external threads of the internal strand to form a relatively point-like contact zone unlike the cords of the prior art in which the direction of winding of the cord is identical to the directions of winding of the external layers of each internal and external strand and in which the external threads of the external strands

cross the external threads of the internal strand to form a less point-like and more linear contact zone, preventing the elastomer compound from passing as far as the internal strand.

[023] As a result of the invention and the relationship between $p2'$ and $p3'$ and because of the relationship between $p1'$ and $p2'$ and the directions of the internal and intermediate layers of each external strand, each external strand has layers that are cylindrical. Very advantageously, the internal strand is a strand with cylindrical layers regardless as to whether this internal strand has two layers or three. It will be recalled that such cylindrical layers are obtained when the various layers of the strand are wound at different pitches one from its pair and/or when the directions of winding of these layers differ from one layer to the other. A strand with cylindrical layers is very highly penetrable, unlike a strand with compact layers in which the pitches of all the layers are the same and the directions of winding of all the layers are the same, and exhibits far lower penetrability.

[024] As an option and a preference, in one embodiment, the cord does not have any polymer compound, notably the cord does not have any sheath of any polymer compound covering the internal strand. In another embodiment, the cord does not have any elastomer compound, notably the cord does not have any sheath of any elastomer compound covering the internal strand.

[025] Advantageously, the cord is made of metal. The term "metal cord" is understood by definition to mean a cord formed of threads made up predominantly (i.e. more than 50% of these threads) or entirely (100% of the threads) of a metallic material. Such a metal cord is preferably implemented with a steel cord, more preferably a cord made of pearlitic (or ferritic-pearlitic) carbon steel referred to as "carbon steel" below, or else made of stainless steel (by definition steel comprising at least 11% chromium and at least 50% iron). However, it is of course possible to use other steels or other alloys.

[026] When a carbon steel is advantageously used, its carbon content (% by weight of steel) is preferably between 0.4% and 1.2%, in particular between 0.5% and 1.1%; these contents represent a good compromise between the mechanical properties required for the tyre and the feasibility of the threads.

[027] The metal or the steel used, whether it is in particular a carbon steel or a stainless steel, may itself be coated with a metallic layer which improves for example the workability of the metallic cord and/or of its constituent elements, or the use properties of the cord and/or of the tyre themselves, such as properties of adhesion, corrosion resistance or resistance to ageing. According to a preferred embodiment, the steel used is covered with a layer of brass (Zn-Cu alloy) or of zinc.

[028] For preference, the threads of the one same layer of a predetermined (internal or external) strand all have substantially the same diameter. Advantageously, the external

strands all have substantially the same diameter. What is meant by “substantially the same diameter” is that the threads or the strands have the same diameter to within the industrial tolerances.

[029] Advantageously, each thread of each strand has a diameter ranging from 0.15 mm to 0.60 mm, preferably from 0.20 mm to 0.50 mm, more preferentially from 0.22 mm to 0.40 mm, and more preferably still from 0.24 mm to 0.35 mm.

[030] What is meant by a polymer compound or a polymeric compound is that the compound contains at least one polymer. For preference, such a polymer may be a thermoplastic, for example a polyester or a polyamide, a thermosetting polymer, an elastomer, for example natural rubber, a thermoplastic elastomer or a combination of these polymers.

[031] What is meant by an elastomer compound or an elastomeric compound is that the compound contains at least one elastomer or one rubber (the two terms being synonyms) and at least one other component. For preference, the elastomer compound also contains a vulcanization system and a filler. More preferentially, the elastomer is a diene elastomer.

[032] Advantageously, the external strands are wound in a helix around the internal strand with a pitch ranging from 40 mm to 100 mm and preferably ranging from 50 mm to 90 mm.

[033] Advantageously:

- $0.36 \leq (p_3' - p_2')/p_3'$, preferably $0.38 \leq (p_3' - p_2')/p_3'$ in instances in which $Q'=2$,
- $0.36 \leq (p_3' - p_2')/p_3'$, preferably $0.38 \leq (p_3' - p_2')/p_3'$ in instances in which $Q'=3$,
- $0.32 \leq (p_3' - p_2')/p_3'$, preferably $0.36 \leq (p_3' - p_2')/p_3'$ in instances in which $Q'=4$.

[034] The higher the ratio $(p_3' - p_2')/p_3'$ or, in other words, the greater the difference between p_3' and p_2' , the better the architectural stability of each external strand. Specifically, the greater the extent to which the pitches of the intermediate and external layers of each external strand differ, the greater the crossing of the intermediate and external threads with respect to one another (contacts between the intermediate and external threads are then relatively point-like contacts), the better the external threads will mechanically hold the intermediate threads and the better will be the penetrability of each external strand of which the threads of the intermediate and external layers will then be evenly distributed within each intermediate and external layer. This mechanical integrity makes it possible to avoid, on the one hand, during manufacture of the cord, all the threads of the intermediate layer all grouping together in contact with one another under the effect of the mechanical forces exerted by the assembly tools and, on the other hand, during manufacture of a ply containing the cord or of the tyre containing the cord, all the threads of the intermediate layer all grouping together in contact with one another

under the effect of the pressure of the elastomer compound penetrating the cord.

[035] Furthermore, for a given pitch p_3' , by increasing the ratio $(p_3'-p_2')/p_3'$, the inter-thread distance of the intermediate layer of each external strand is reduced. A person skilled in the art would expect to see a drop in the penetrability of each external strand. Yet, entirely unexpectedly, as the comparative tests described hereinafter show, by increasing the ratio $(p_3'-p_2')/p_3'$, although the inter-thread distance of the intermediate layer of each external strand is admittedly reduced, the size of the radial passage windows for the elastomer compound is increased which means that the penetrability of each external strand is appreciably improved.

[036] Advantageously:

- $(p_3'-p_2')/p_3' \leq 0.42$ and preferably $(p_3'-p_2')/p_3' \leq 0.40$ in instances in which $Q'=2$,
- $(p_3'-p_2')/p_3' \leq 0.40$ in instances in which $Q'=3$,
- $(p_3'-p_2')/p_3' \leq 0.40$ and preferably $(p_3'-p_2')/p_3' \leq 0.38$ in instances in which $Q'=4$.

Below these values, the size of the radial passage windows for the elastomer compound is at a maximum and makes it possible to optimize the penetrability of each external strand.

[037] Advantageously, the pitch p_1' is such that $3 \text{ mm} \leq p_1' \leq 16 \text{ mm}$, preferably $4 \text{ mm} \leq p_1' \leq 13 \text{ mm}$ and more preferably $5 \text{ mm} \leq p_1' \leq 10 \text{ mm}$.

[038] Advantageously, the pitch p_2' is such that $8 \text{ mm} \leq p_2' \leq 20 \text{ mm}$, preferably $9 \text{ mm} \leq p_2' \leq 18 \text{ mm}$ and more preferably $10 \text{ mm} \leq p_2' \leq 16 \text{ mm}$.

[039] Advantageously, the pitch p_3' is such that $10 \text{ mm} \leq p_3' \leq 40 \text{ mm}$, preferably $12 \text{ mm} \leq p_3' \leq 30 \text{ mm}$ and more preferably $15 \text{ mm} \leq p_3' \leq 25 \text{ mm}$.

[040] Pitches p_1' , p_2' and p_3' within these preferred ranges make it possible to obtain a cord that exhibits mechanical properties compatible with tyre use, a relatively low cost and a relatively low linear cord weight.

[041] By definition, the diameter of a strand is the diameter of the smallest circle inside which the strand can be circumscribed. The internal strand TI has a diameter DI and each external strand TE has a diameter DE.

[042] Advantageously, in instances in which $L=6$, $DI/DE > 1$, for preference $DI/DE \geq 1.05$ and more preferably $DI/DE \geq 1.10$. This then better promotes the passage of the elastomer compound between the external strands. Advantageously, in instances in which $L=6$, $DI/DE \leq 1.40$, for preference $DI/DE \leq 1.35$ and more preferably $DI/DE \leq 1.30$. This then avoids having excessive space between the external strands so as to ensure, on the one hand, the architectural stability of the cord and, on the other hand, to maximize the force at break by laying as many external strands as possible while at the same time allowing the elastomer compound to pass between the external strands. This then limits the external diameter of the cord and therefore maximizes the mass of metal

that can be laid in a ply. Furthermore, the thickness of the ply is reduced, as therefore are the heating, rolling resistance and mass of the tyre.

[043] In addition, for these preferential values of DI/DE , while promoting the passage of the elastomer compound between the external strands still further, the restoration of the arch of the cord is promoted.

[044] Advantageously, in instances in which $L=7$, $DI/DE \geq 1.30$, for preference $DI/DE \geq 1.35$ and more preferably $DI/DE \geq 1.40$. Advantageously, in instances in which $L=7$, $DI/DE \leq 1.70$, for preference $DI/DE \leq 1.65$ and more preferably $DI/DE \leq 1.60$.

[045] Advantageously, in instances in which $L=8$, $DI/DE \geq 1.60$, for preference $DI/DE \geq 1.65$ and more preferably $DI/DE \geq 1.70$. Advantageously, in instances in which $L=8$, $DI/DE \leq 2.0$, for preference $DI/DE \leq 1.95$ and more preferably $DI/DE \leq 1.90$.

[046] Advantageously, in instances in which $L=9$, $DI/DE \geq 2.00$, for preference $DI/DE \geq 2.05$ and more preferably $DI/DE \geq 2.10$. Advantageously, in instances in which $L=9$, $DI/DE \leq 2.50$, for preference $DI/DE \leq 2.45$ and more preferably $DI/DE \leq 2.40$.

[047] In a similar way to the instance in which $L=6$, for instances in which $L=7, 8$ or 9 , for relatively high values of DI/DE , the passage of the elastomer compound between the external strands is further promoted, and, for relatively low values of DI/DE , the architectural stability of the cord is ensured, the force at break is maximized while at the same time allowing the elastomer compound to pass between the external strands, the external diameter of the cord is limited, and the thickness of the ply is reduced, as therefore are the heating, rolling resistance and mass of the tyre. Finally, the arch of the cord is also restored.

[048] In one embodiment, L is equal to $6, 7, 8, 9$ or 10 , for preference $L=6, 7$ or 8 and more preferably $L=6$.

[049] In an embodiment that promotes the penetrability of the cord, the external layer of the cord is completely unsaturated.

[050] By definition, a completely unsaturated layer of strands is, as opposed to an incompletely unsaturated layer, such that there is sufficient space in this layer to add in at least one $(X+1)$ th strand having the same diameter as the X strands of the layer, it thus being possible for a plurality of strands to be, or to not be, in contact with one another. In this particular instance, there is enough space in the external layer of the cord to add in at least one $(L+1)$ th strand having the same diameter as the L external strands of the external layer of the cord. Thus, advantageously, the sum SIE of the inter-strand distances E of the external layer of the cord is such that $SIE \geq DE$. The sum SIE is the sum of the inter-strand distances E separating each pair of adjacent strands in the layer. The inter-strand distance of a layer is defined, in a section of the cord perpendicular to the main axis of the cord, as being the shortest distance, which, on

average, separates two adjacent strands of the layer. Thus, the inter-strand distance E is calculated by dividing the sum SIE by the number of spaces separating the strands in the layer.

[051] In another embodiment that promotes the compromise between penetrability and force at break, the external layer of the cord is incompletely unsaturated.

[052] An incompletely unsaturated layer of strands is such that there is not enough space in this layer to add in at least one $(X+1)^{th}$ strand having the same diameter as the X strands of the layer. In this particular instance, there is not enough space in the external layer to add in at least one $(L+1)^{th}$ external strand having the same diameter as the L external strands of the external layer of the cord. Thus, the sum SIE of the inter-strand distances E of the external layer of the cord is such that $SIE < DE$.

[053] Optionally, each external thread of the internal strand has a diameter d_3 greater than or equal to the diameter d_3' of each external thread of each external strand, for preference each external thread of the internal strand has a diameter d_3 greater than the diameter d_3' of each external thread of each external strand. For preference, by virtue of the characteristic $d_3 > d_3'$, each external thread of the internal strand may be able to withstand the radial component of the force exerted by the external strands on the internal strand when the cord is under tension. This characteristic $d_3 > d_3'$ makes it possible to restore, or even to improve, the breaking force of the cord by comparison with a cord comprising an arch formed by the external strands or by comparison with a cord in which $d_3 \leq d_3'$. For preference, $1 < d_3/d_3' \leq 2$, more preferably $1 < d_3/d_3' \leq 1.5$ and more preferably still $1 < d_3/d_3' \leq 1.25$ or $1.25 < d_3/d_3' \leq 1.5$.

[054] External strands of the cord according to the invention

[055] In preferred embodiments, $M'=7, 8, 9$ or 10 , $N'=12, 13, 14$ or 15 .

[056] In a first variant, $Q'=2$, $M'=7$ or 8 and $N'=12$ or 13 . Instances in which $M'=7$ and/or $N'=12$, favour the desaturation of the intermediate or external layer of each external strand and therefore the penetrability of the cord through the external strands. Instances in which $M'=8$ and/or $N'=13$ maximize the number of intermediate or external strands and therefore the force at break of the cord.

[057] In a second variant, $Q'=3$, $M'=8$ or 9 and $N'=13$ or 14 . Instances in which $M'=8$ and/or $N'=13$, favour the desaturation of the intermediate or external layer of each external strand and therefore the penetrability of the cord through the external strands. Instances in which $M'=9$ and/or $N'=14$ maximize the number of intermediate or external strands and therefore the force at break of the cord.

[058] In a third variant, $Q'=4$, $M'=9$ or 10 and $N'=14$ or 15 . Instances in which $M'=9$ and/or $N'=14$, favour the desaturation of the intermediate or external layer of each

external strand and therefore the penetrability of the cord through the external strands. Instances in which $M'=10$ and/or $N'=15$ maximize the number of intermediate or external strands and therefore the force at break of the cord.

[059] In these embodiments, notably those in which $Q'=3$ or 4 , there is a risk of seeing a significant spread of corrosive agents between the $Q'=3$ or 4 internal threads which delimit a central capillary which very much encourages them to spread along the strand, when the strand is insufficiently penetrated. This disadvantage can be overcome by rendering the strand capable of being penetrated by the elastomer compound which then prevents the corrosive agents from accessing the central capillary and, in the best of cases in which the central capillary is itself penetrated, prevents these corrosive agents from spreading along the strand.

[060] Advantageously, the sum $SI2'$ of the inter-wire distances of the intermediate layer is such that $SI2' < d3'$ where $d3'$ is the diameter of each external wire of each external strand, preferably $SI2' \leq 0.8 \times d3'$. The sum $SI2'$ is the sum of the inter-thread distances separating each pair of adjacent threads in the intermediate layer. The inter-thread distance of a layer is defined, in a section of the cord perpendicular to the main axis of the cord, as being the shortest distance, which, on average, separates two adjacent threads of the layer. Thus, the inter-thread distance is calculated by dividing the sum $SI2'$ by the number of spaces separating the threads in the intermediate layer. Because the diameter $d3'$ of the external threads of the external layer of each external strand is preferably greater than the sum $SI2'$, the external threads are prevented from penetrating the intermediate layer. This then ensures good architectural stability, thereby additionally reducing the risk of alteration to the radial passage windows for the elastomer compound and therefore the risk of degrading the good penetrability of each external strand.

[061] Advantageously, the intermediate layer of each external strand is desaturated.

[062] By definition, a layer of threads that is desaturated with threads is one such that there is enough space left between the threads to allow an elastomer compound to pass. Thus, a layer that is desaturated means that the threads in this layer do not touch and that there is enough space between two adjacent threads in the layer to allow an elastomer compound to pass through the layer. By contrast, a layer of strands that is saturated is such that there is not enough space between the threads of the layer to allow an elastomer compound to pass, for example because each pair of two threads of the layer touch one another.

[063] Advantageously, the inter-thread distance of the intermediate layer of each external strand is greater than or equal to $5 \mu\text{m}$. For preference, the inter-thread distance in the intermediate layer of each external strand is greater than or equal to $15 \mu\text{m}$, more preferably greater than or equal to $35 \mu\text{m}$, more preferably still greater than or equal to

50 μm and highly preferably greater than or equal to 60 μm .

[064] The fact that the intermediate layer of each external strand is desaturated advantageously makes it easier for the elastomer compound to pass as far as the centre of each external strand, and thus render each external strand less sensitive to corrosion.

[065] In an embodiment that promotes the compromise between penetrability of each external strand and force at break, the intermediate layer of each external strand is incompletely unsaturated.

[066] By definition, an incompletely unsaturated layer of threads is such that there is not enough space in this layer to add in at least one $(X'+1)^{\text{th}}$ thread having the same diameter as the X' threads of the layer. In this particular instance, there is not enough space in the intermediate layer to add in at least one $(M'+1)^{\text{th}}$ intermediate thread having the same diameter as the M' intermediate threads of the intermediate layer. In other words, what is meant by an incompletely unsaturated intermediate layer of external strands is that the sum $SI2'$ of the inter-thread distances $I2'$ of the intermediate layer is less than the diameter $d2'$ of the intermediate threads of the intermediate layer. Thus, advantageously, the sum $SI2'$ of the inter-thread distances of the intermediate layer of each external strand is such that $SI2' < d2'$.

[067] The fact that the intermediate layer of each external strand is incompletely unsaturated makes it possible to ensure the architectural stability of the intermediate layer. This then reduces the risk of an external thread penetrating the intermediate layer, something which would alter the radial passage windows for the elastomer compound and therefore degrade the good penetrability of each external strand. Furthermore, the fact that the intermediate layer of each external strand is incompletely unsaturated makes it possible to ensure that each external strand comprises a relatively high number of intermediate threads and therefore exhibits a relatively high force at break.

[068] In another embodiment that promotes the penetrability of each external strand, the intermediate layer of each external strand is completely unsaturated.

[069] By definition, a completely unsaturated layer of threads is such that there is sufficient room in this layer to add at least one $(X'+1)^{\text{th}}$ thread having the same diameter as the X' threads of the layer thereto, it thus being possible for a plurality of threads to be in contact, or not in contact, with one another. In this particular instance, there is enough space in the intermediate layer of each external strand to add in at least one $(M'+1)^{\text{th}}$ intermediate thread having the same diameter as the M' intermediate threads of the intermediate layer. In other words, what is meant by a completely unsaturated intermediate layer of external strands is that the sum $SI2'$ of the inter-thread distances $I2'$ of the intermediate layer is greater than or equal to the diameter $d2'$ of the intermediate threads of the intermediate layer. Thus, advantageously, the sum $SI2'$ of

the inter-thread distances of the intermediate layer of each external strand is such that $SI2' \geq d2'$.

[070] Advantageously, the external layer of each external strand is desaturated, preferably completely unsaturated. In a way similar to the case with the intermediate layer, the fact that the external layer of each external strand is desaturated advantageously makes it easier for the elastomer compound to pass into and through each external strand, and thus render each external strand less sensitive to corrosion.

[071] Advantageously, the inter-thread distance of the external layer of each external strand is greater than or equal to 5 μm . For preference, the inter-thread distance of the external layer of each external strand is greater than or equal to 15 μm , more preferably greater than or equal to 35 μm , more preferably still greater than or equal to 50 μm and highly preferably greater than or equal to 60 μm .

[072] By definition, a completely unsaturated layer of threads is such that there is sufficient room in this layer to add at least one $(X'+1)^{\text{th}}$ thread having the same diameter as the X' threads of the layer thereto, it thus being possible for a plurality of threads to be in contact, or not in contact, with one another. In this particular instance, there is enough space in the external layer of each external strand to add in at least one $(N'+1)^{\text{th}}$ external thread having the same diameter as the N' external threads of the external layer. In other words, what is meant by a completely unsaturated external layer of external strands is that the sum $SI3'$ of the inter-thread distances $I3'$ of the external layer is greater than the diameter $d3'$ of the external threads of the external layer. Thus, advantageously, the sum $SI3'$ of the inter-thread distances of the external layer of each external strand is such that $SI3' \geq d3'$. The sum $SI3'$ is the sum of the inter-thread distances separating each pair of adjacent threads in the external layer. The inter-thread distance of a layer is defined, in a section of the cord perpendicular to the main axis of the cord, as being the shortest distance, which, on average, separates two adjacent threads of the layer. Thus, the inter-thread distance is calculated by dividing the sum $SI3'$ by the number of spaces separating the threads in the external layer.

[073] The fact that the external layer of each external strand is completely unsaturated makes it possible to maximize the penetration of the elastomer compound into each external strand, and thus render each external strand even less sensitive to corrosion.

[074] In some preferred embodiments, each internal thread of each external strand has a diameter $d1'$ greater than or equal to the diameter $d2'$ of each intermediate thread of each external strand, and highly preferably $1 \leq d1'/d2' \leq 1.10$. The use of diameters such that $d1' > d2'$ makes it possible to promote the penetrability of the elastomer compound through the intermediate layer. When $d1' > d2'$, then very preferably $d1'/d2' \leq 1.10$, which makes it possible, on the one hand, to control the architectural stability of the

intermediate layer and, on the other hand, to render the present invention even more beneficial because of the relatively small amount of desaturation created by the difference between $d1'$ and $d2'$. The use of diameters such that $d1'=d2'$ makes it possible to limit the number of different threads to be managed in the manufacture of the cord, and also makes it possible to render the present invention even more beneficial because of the lack of desaturation created by the equality between $d1'$ and $d2'$.

[075] In some preferred embodiments, each internal thread of each external strand has a diameter $d1'$ greater than or equal to the diameter $d3'$ of each external thread of each external strand, and highly preferably $1 \leq d1'/d3' \leq 1.10$. The use of diameters such that $d1' > d3'$ makes it possible to promote the penetrability of the elastomer compound through the external layer. When $d1' > d3'$, then very preferably $d1'/d3' \leq 1.10$, which makes it possible, on the one hand, to control the architectural stability of the external layer and, on the other hand, to render the present invention even more beneficial because of the relatively small amount of desaturation created by the difference between $d1'$ and $d3'$. The use of diameters such that $d1'=d3'$ makes it possible to limit the number of different threads to be managed in the manufacture of the cord, and also makes it possible to render the present invention even more beneficial because of the lack of desaturation created by the equality between $d1'$ and $d3'$.

[076] In some preferred embodiments, each intermediate thread of each external strand has a diameter $d2'$ equal to the diameter $d3'$ of each external thread of each external strand. The use of diameters such that $d2'=d3'$ makes it possible to limit the number of different threads to be managed in the manufacture of the cord.

[077] Advantageously, each external strand is of the type not rubberized in situ. What is meant by not rubberized in situ is that, prior to the assembly of the external layer of the cord, and prior to the assembly of the cord, each external strand is made up of the threads of the various layers and does not have any polymer compound, notably any elastomer compound.

[078] Internal strand of the cord according to the invention

[079] Advantageously, the external layer of the internal strand is desaturated, preferably completely unsaturated. The fact that the external layer of the internal strand is desaturated advantageously makes it easier for the elastomer compound to pass as far as the centre of the internal strand, and thus render the internal strand less sensitive to corrosion.

[080] Advantageously, the inter-thread distance of the external layer of the internal

strand is greater than or equal to 5 μm . For preference, the inter-thread distance of the external layer of the internal strand is greater than or equal to 15 μm , more preferably greater than or equal to 35 μm , more preferably still greater than or equal to 50 μm and highly preferably greater than or equal to 60 μm .

[081] The external layer of the internal strand is preferably completely unsaturated.

[082] By definition, a completely unsaturated layer of threads is such that there is sufficient room in this layer to add at least one $(X+1)^{\text{th}}$ thread having the same diameter as the X threads of the layer thereto, it thus being possible for a plurality of threads to be in contact, or not in contact, with one another. In this particular instance, there is enough space in the external layer to add in at least one $(N+1)^{\text{th}}$ thread having the same diameter as the N threads of the external layer. In other words, what is meant by a completely unsaturated external layer of internal strands is that the sum SI3 of the inter-thread distances I3 of the external layer is greater than or equal to the diameter d3 of the external threads of the external layer. Thus, advantageously, the sum SI3 of the inter-strand distances of the external layer of the internal strand is such that $\text{SI3} \geq d3$. The sum SI3 is the sum of the inter-thread distances separating each pair of adjacent threads in the external layer. The inter-thread distance of a layer is defined, in a section of the cord perpendicular to the main axis of the cord, as being the shortest distance, which, on average, separates two adjacent threads of the layer. Thus, the inter-thread distance is calculated by dividing the sum SI3 by the number of spaces separating the threads in the external layer.

[083] The fact that the external layer of the internal strand is completely unsaturated makes it possible to maximize the penetration of the elastomer compound into the internal strand, and thus render the internal strand even less sensitive to corrosion.

[084] In some preferred embodiments, each internal thread of the internal strand has a diameter d1 greater than or equal to the diameter d3 of each external thread of the internal strand, and highly preferably $1 \leq d1/d3 \leq 1.10$. The use of diameters such that $d1 > d3$ makes it possible to promote the penetrability of the elastomer compound through the external layer. When $d1 > d3$, then very preferably $d1/d3 \leq 1.10$, which makes it possible, on the one hand, to control the architectural stability of the external layer and, on the other hand, to render good penetrability of the internal strand even more beneficial because of the relatively small amount of desaturation created by the difference between d1 and d3. The use of diameters such that $d1 = d3$ makes it possible to limit the number of different threads to be managed in the manufacture of the cord, and also makes it possible to render the present invention even more beneficial because of the lack of desaturation created by the equality between d1 and d3.

[085] In one embodiment, the internal strand is of the type rubberized in situ. Such a

strand comprises, prior to assembly of the cord, a layer of a polymer compound, notably an elastomer compound, arranged between at least two radially adjacent layers of threads, possibly between each of the radially adjacent layers of threads. Such a strand that is rubberized in situ is notably described in WO2010054790.

[086] In another embodiment, the internal strand is of the type not rubberized in situ. What is meant by not rubberized in situ is that, prior to the assembly of the cord, the internal strand is made up of the threads of the various layers and does not have any polymer compound, notably any elastomer compound.

[087] Two-layer internal strand

[088] In one embodiment which favours the compromise between the diameter of the cord and the force at break, the internal strand has two layers. In this embodiment, the external layer of the internal strand is wound around the internal layer of the internal strand in contact with the internal layer of the internal strand. In this embodiment, the internal strand comprises a collection of threads which is made up of two layers of threads, neither more nor less, which means to say that the collection of threads has two layers of threads, not one, not three, but only two.

[089] In preferred embodiments, $Q=1, 2, 3$ or 4 .

[090] In one embodiment, $Q=1$, $N=5$ or 6 , and preferably $Q=1$, $N=6$.

[091] In preferred embodiments that make it possible to increase the force at break of the cord with respect to the prior art in which $Q=1$, $Q=2, 3$ or 4 , preferably $Q=3$ or 4 . Unlike in the embodiment in which $Q=1$ and in which there is a risk of seeing the internal thread of the internal strand pop radially out of the internal strand and even out of the cord, under the effect of the repeated compressive loadings applied to the cord, the presence of several threads in the internal layer of each internal strand ($Q>1$), makes it possible to reduce this risk as the compressive forces are then distributed over the plurality of threads of the internal layer.

[092] In these embodiments in which $Q>1$, there is advantageously an internal strand with cylindrical layers, that is to say a strand in which the Q internal threads wound with a pitch p_1 and in an internal strand internal layer direction and the N external threads are wound around the intermediate layer with a pitch p_3 and in an internal strand external layer direction, p_1 being different from p_3 and/or the internal strand internal layer direction being different from the internal strand external layer direction.

[093] In these preferred embodiments $Q>1$, notably those in which $Q=3$ or 4 , there is a risk, when the cord is insufficiently penetrated, of seeing a significant spread of corrosive agents between the $Q=3$ or 4 internal threads which delimit a central capillary which very much encourages them to spread along each strand. This disadvantage can be

overcome by a rendering the strand capable of being penetrated by the elastomer compound which then prevents the corrosive agents from accessing the central capillary and, in the best of cases in which the central capillary is itself penetrated, prevents these corrosive agents from spreading along the strand.

[094] In preferred embodiments in which $Q > 1$, $N = 7, 8, 9$ or 10 , for preference $N = 8, 9$ or 10 and more preferably $N = 8$ or 9 .

[095] In a first alternative form, $Q = 2$ and $N = 7$ or 8 , for preference $Q = 2$, $N = 7$.

[096] In a second alternative form, $Q = 3$ and $N = 7, 8$ or 9 , for preference $Q = 3$, $N = 8$.

[097] In a third variant, $Q = 4$ and $N = 7, 8, 9$ or 10 , for preference $Q = 4$, $N = 9$.

[098] In a first embodiment of the cord, the intermediate layer of each external strand is wound around the internal layer of each external strand in a direction of winding identical to the direction of winding of the cord.

[099] In a first alternative of this first embodiment, in the case that $Q > 1$, the internal layer of the internal strand is wound in a helix with a direction of winding identical to the direction of winding of the cord.

[0100] In a second alternative of this first embodiment, in the case that $Q > 1$, the internal layer of the internal strand is wound in a helix with a direction of winding opposite to the direction of winding of the cord.

[0101] In each of the first and second alternative forms of this first embodiment which have been described hereinabove, the internal layer of each external strand is wound in a helix with a direction of winding identical to the direction of winding of the cord or, as an alternative, in a direction of winding opposite to the direction of winding of the cord. As a preference, the internal layer of each external strand is wound in a helix in a direction of winding identical to the direction of winding of the intermediate layer of each external strand.

[0102] In a second embodiment of the cord, the intermediate layer of each external strand is wound around the internal layer of each external strand in a direction of winding opposite to the direction of winding of the cord.

[0103] In a first alternative of this second embodiment, in the case that $Q > 1$, the internal layer of the internal strand is wound in a helix with a direction of winding identical to the direction of winding of the cord.

[0104] In a second alternative of this second embodiment, in the case that $Q > 1$, the internal layer of the internal strand is wound in a helix with a direction of winding opposite to the direction of winding of the cord. In this particularly preferred second alternative form of the second embodiment of the cord, the rubbing-together of the threads of the adjacent layers and therefore the wearing thereof is limited.

[0105] In each of the first and second alternative forms of this second embodiment which

have been described hereinabove, the internal layer of each external strand is wound in a helix with a direction of winding identical to the direction of winding of the cord or, as an alternative, in a direction of winding opposite to the direction of winding of the cord. As a preference, the internal layer of each external strand is wound in a helix in a direction of winding identical to the direction of winding of the intermediate layer of each external strand.

[0106] Thus, in the context of the invention, in the case of an internal strand having 2 layers, it is possible to envisage the combinations of direction of winding that have been collated in Table A below:

Cord									
Internal strand	Direction for C1	S	Z	Z	S	S	Z	Z	S
	Direction for C3	Z	Z	S	S	Z	Z	S	S
External strand	Direction for C1'	S or Z	S or Z	S or Z	S or Z	S or Z	S or Z	S or Z	S or Z
	Direction for C2'	S	S	Z	Z	Z	Z	S	S
	Direction for C3'	Z	Z	S	S	Z	Z	S	S
Direction of winding of the cord		S	S	Z	Z	S	S	Z	Z

Table A

[0107] Three-layer internal strand

[0108] In another particularly advantageous embodiment that improves the force at break of the cord, the internal strand has three layers and comprises:

- an internal layer made up of $Q \geq 1$ internal threads,
- an intermediate layer made up of $M > 1$ intermediate threads wound around the internal layer, and
- an external layer made up of $N > 1$ external threads wound around the intermediate layer.

[0109] In this embodiment, the external layer of the internal strand is wound around the intermediate layer of the internal strand in contact with the intermediate layer of the internal strand and the intermediate layer of the internal strand is wound around the

internal layer of the internal strand in contact with the internal layer of the internal strand. In this embodiment, the internal strand comprises a collection of threads which is made up of three layers of threads, neither more nor less, which means to say that the collection of threads has three layers of threads, not two, not four, but only three.

[0110] In preferred embodiments, $Q=1, 2, 3$ or 4 .

[0111] In some embodiments, $Q = 1$. In the embodiment in which $Q = 1$, and when the cord, unlike that of the invention, is insufficiently penetrated, there is a risk of seeing the internal thread of the internal strand radially leave the internal strand and even the cord, under the effect of the repeated compressive loadings applied to the cord. By virtue of the invention, because of the excellent penetration of the internal strand and despite the fact that $Q=1$, the elastomer compound acts like a wrapping layer around the internal strand, notably around the external and intermediate layers of the internal strand, preventing the internal thread from coming out, even under the repeated compressive loadings.

[0112] In these embodiments in which $Q=1$, there is advantageously an internal strand with cylindrical layers, that is to say a strand in which the M intermediate threads are wound around the internal layer with a pitch p_2 and in an internal strand intermediate layer direction and the N external threads are wound around the intermediate layer with a pitch p_3 and in an internal strand external layer direction, p_2 being different from p_3 and/or the internal strand intermediate layer direction being different from the internal strand external layer direction.

[0113] In one embodiment, $Q=1$, $M= 5$ or 6 and $N=10, 11$ or 12 , for preference $Q=1$, $M=5$ or 6 and $N=10$ or 11 and more preferably $Q=1$, $M=6$ and $N=11$.

[0114] In preferred embodiments that make it possible to increase the force at break of the cord with respect to the prior art in which $Q=1$, $Q=2, 3$ or 4 , preferably $Q=3$ or 4 .

[0115] In these embodiments in which $Q>1$, there is advantageously an internal strand with cylindrical layers, that is to say a strand in which the Q internal threads are wound with a pitch p_1 and in an internal strand internal layer direction and the M intermediate threads are wound around the internal layer with a pitch p_2 and in an internal strand intermediate layer direction, the N external threads wound around the intermediate layer with a pitch p_3 and in an internal strand external layer direction, p_1, p_2 and p_3 each being different one from another and/or the directions of the adjacent layers of the internal strand being different.

[0116] In addition, for preference, the M intermediate threads wound around the internal layer with a pitch p_2 and the N external threads wound around the intermediate layer with a pitch p_3 , the pitches p_2 and p_3 satisfying:

$$- 0.33 \leq (p_3 - p_2)/p_3 \leq 0.45 \text{ in instances in which } Q=2,$$

- $0.35 \leq (p_3 - p_2)/p_3 \leq 0.42$ in instances in which $Q=3$,
- $0.28 \leq (p_3 - p_2)/p_3 \leq 0.43$ in instances in which $Q=4$,

[0117] Such a ratio $(p_3 - p_2)/p_3$ makes it possible to obtain relatively large radial passage windows for the elastomer compound within the internal strand.

[0118] Advantageously, the pitches p_2 and p_3 satisfy the relationship:

- $0.36 \leq (p_3 - p_2)/p_3$, preferably $0.38 \leq (p_3 - p_2)/p_3$ in instances in which $Q=2$,
- $0.36 \leq (p_3 - p_2)/p_3$, preferably $0.38 \leq (p_3 - p_2)/p_3$ in instances in which $Q=3$,
- $0.32 \leq (p_3 - p_2)/p_3$, preferably $0.36 \leq (p_3 - p_2)/p_3$ in instances in which $Q=4$.

[0119] In a similar way to the external strands, the higher the ratio $(p_3 - p_2)/p_3$ or, in other words, the greater the difference between p_3 and p_2 , the better the architectural stability of the internal strand.

[0120] Advantageously, the pitches p_2 and p_3 satisfy the relationship:

- $(p_3 - p_2)/p_3 \leq 0.42$ and preferably $(p_3 - p_2)/p_3 \leq 0.40$ in instances in which $Q=2$,
- $(p_3 - p_2)/p_3 \leq 0.40$ in instances in which $Q=3$,
- $(p_3 - p_2)/p_3 \leq 0.40$ and preferably $(p_3 - p_2)/p_3 \leq 0.38$ in instances in which $Q=4$.

[0121] Below these values, the size of the radial passage windows for the elastomer compound is at a maximum and makes it possible to optimize the penetrability of the internal strand.

[0122] Advantageously, the pitch p_1 is such that $3 \text{ mm} \leq p_1 \leq 16 \text{ mm}$, preferably $4 \text{ mm} \leq p_1 \leq 13 \text{ mm}$ and more preferably $5 \text{ mm} \leq p_1 \leq 10 \text{ mm}$.

[0123] Advantageously, the pitch p_2 is such that $8 \text{ mm} \leq p_2 \leq 20 \text{ mm}$, preferably $9 \text{ mm} \leq p_2 \leq 18 \text{ mm}$ and more preferably $10 \text{ mm} \leq p_2 \leq 16 \text{ mm}$.

[0124] Advantageously, the pitch p_3 is such that $10 \text{ mm} \leq p_3 \leq 40 \text{ mm}$, preferably $12 \text{ mm} \leq p_3 \leq 30 \text{ mm}$ and more preferably $15 \text{ mm} \leq p_3 \leq 25 \text{ mm}$.

[0125] Pitches p_1 , p_2 and p_3 within these preferred ranges make it possible to obtain a cord that exhibits mechanical properties compatible with tyre use, a relatively low cost and a relatively low linear cord weight.

[0126] In these preferred embodiments $Q > 1$, notably those in which $Q=3$ or 4 , there is a risk, when the cord is insufficiently penetrated, of seeing a significant spread of corrosive agents between the $Q=3$ or 4 internal threads which delimit a central capillary which very much encourages them to spread along each strand. This disadvantage can be overcome by rendering the strand capable of being penetrated by the elastomer compound which then prevents the corrosive agents from accessing the central capillary and, in the best of cases in which the central capillary is itself penetrated, prevents these corrosive agents from spreading along the strand.

[0127] In preferred embodiments in which $Q > 1$, $Q = 2, 3$ or 4 , $M = 7, 8, 9$ or 10 , $N = 13, 14$ or 15 , preferably $Q = 3$ or 4 , $M = 8, 9$ or 10 , $N = 14$ or 15 , more preferably $Q = 3$, $M = 8$ or 9 and $N = 14$ or 15 and more preferably still, $Q = 3$, $M = 9$ and $N = 15$.

[0128] Advantageously, the sum SI_2 of the inter-thread distances of the intermediate layer is such that $SI_2 < d_3$ where d_3 is the diameter of each external thread of the internal strand, preferably $SI_2 \leq 0.8 \times d_3$. In a similar way to the external strand, because the diameter d_3 of the external threads of the external layer of the internal strand is preferably greater than the sum SI_2 , the external threads are prevented from penetrating the intermediate layer. This then ensures good architectural stability, thereby reducing the risk of alteration to the radial passage windows for the elastomer compound and therefore the risk of degrading the good penetrability of the internal strand. The sum SI_2 is the sum of the inter-thread distances separating each pair of adjacent threads in the intermediate layer. The inter-thread distance of a layer is defined, in a section of the cord perpendicular to the main axis of the cord, as being the shortest distance, which, on average, separates two adjacent threads of the layer. Thus, the inter-thread distance is calculated by dividing the sum SI_2 by the number of spaces separating the threads in the intermediate layer.

[0129] Advantageously, the intermediate layer of the internal strand is desaturated.

[0130] Advantageously, the inter-thread distance of the intermediate layer of the internal strand is greater than or equal to $5 \mu\text{m}$. For preference, the inter-thread distance in the intermediate layer of the internal strand is greater than or equal to $15 \mu\text{m}$, more preferably greater than or equal to $35 \mu\text{m}$, more preferably still greater than or equal to $50 \mu\text{m}$ and highly preferably greater than or equal to $60 \mu\text{m}$.

[0131] The fact that the intermediate layer of the internal strand is desaturated advantageously makes it easier for the elastomer compound to pass as far as the centre of the internal strand, and thus render the internal strand less sensitive to corrosion.

[0132] In an embodiment that promotes the compromise between penetrability of the internal strand and force at break, the intermediate layer of the internal strand is incompletely unsaturated.

[0133] By definition, an incompletely unsaturated layer of threads is such that there is not enough space in this layer to add in at least one $(X+1)^{\text{th}}$ thread having the same diameter as the X threads of the layer. In this particular instance, there is not enough space in the intermediate layer to add in at least one $(M+1)^{\text{th}}$ intermediate thread having the same diameter as the M intermediate threads of the intermediate layer. In other words, what is meant by an incompletely unsaturated intermediate layer of internal strands is that the sum SI_2 of the inter-thread distances I_2 of the intermediate layer is less than the diameter d_2 of the intermediate threads of the intermediate layer. Thus,

advantageously, the sum SI_2 of the inter-strand distances of the intermediate layer of the internal strand is such that $SI_2 < d_2$.

[0134] The fact that the intermediate layer of the internal strand is incompletely unsaturated makes it possible to ensure the architectural stability of the intermediate layer. Furthermore, the fact that the intermediate layer of the internal strand is incompletely unsaturated makes it possible to ensure that the internal strand comprises a relatively high number of intermediate threads and therefore exhibits a relatively high force at break.

[0135] In another embodiment that promotes the penetrability of the internal strand, the intermediate layer of the internal strand is completely unsaturated.

[0136] By definition, a completely unsaturated layer of threads is such that there is sufficient room in this layer to add at least one $(X+1)^{th}$ thread having the same diameter as the X threads of the layer thereto, it thus being possible for a plurality of threads to be in contact, or not in contact, with one another. In this particular instance, there is enough space in the intermediate layer of the internal strand to add in at least one $(M+1)^{th}$ intermediate thread having the same diameter as the M intermediate threads of the intermediate layer. In other words, what is meant by a completely unsaturated intermediate layer of internal strands is that the sum SI_2 of the inter-thread distances I_2 of the intermediate layer is greater than or equal to the diameter d_2 of the intermediate threads of the intermediate layer. Thus, advantageously, the sum SI_2 of the inter-strand distances of the intermediate layer of the internal strand is such that $SI_2 \geq d_2$.

[0137] In some preferred embodiments, each internal thread of the internal strand has a diameter d_1 greater than or equal to the diameter d_2 of each intermediate thread of the internal strand, and highly preferably $1 \leq d_1/d_2 \leq 1.10$. The use of diameters such that $d_1 > d_2$ makes it possible to promote the penetrability of the elastomer compound through the intermediate layer. When $d_1 > d_2$, then very preferably $d_1/d_2 \leq 1.10$, which makes it possible, on the one hand, to control the architectural stability of the intermediate layer and, on the other hand, to render good penetrability of the internal strand even more beneficial because of the relatively small amount of desaturation created by the difference between d_1 and d_2 . The use of diameters such that $d_1 = d_2$ makes it possible to limit the number of different threads to be managed in the manufacture of the cord, and also makes it possible to render the present invention even more beneficial because of the lack of desaturation created by the equality between d_1 and d_2 .

[0138] In some preferred embodiments, each intermediate thread of the internal strand has a diameter d_2 equal to the diameter d_3 of each external thread of the internal strand. The use of diameters such that $d_2 = d_3$ makes it possible to limit the number of different threads to be managed in the manufacture of the cord.

[0139] In a first embodiment of the cord, the intermediate layer of each external strand is wound around the internal layer of each external strand in a direction of winding identical to the direction of winding of the cord.

[0140] In a first alternative form of this first embodiment, the intermediate layer of the internal strand is wound around the internal layer of the internal strand in a direction of winding identical to the direction of winding of the cord.

[0141] In a second alternative form of this first embodiment, the intermediate layer of the internal strand is wound around the internal layer of the internal strand in a direction of winding opposite to the direction of winding of the cord.

[0142] In each of the first and second alternative forms of this first embodiment which have been described hereinabove, in the case that $Q > 1$, the internal layer of the internal strand is wound in a helix in a direction of winding identical to the direction of winding of the cord or, as an alternative, in a direction of winding opposite to the direction of winding of the cord. As a preference, the internal layer of the internal strand is wound in a helix in a direction of winding identical to the direction of winding of the intermediate layer of the internal strand.

[0143] In each of the first and second alternative forms of this first embodiment which have been described hereinabove, the internal layer of each external strand is wound in a helix with a direction of winding identical to the direction of winding of the cord or, as an alternative, in a direction of winding opposite to the direction of winding of the cord. As a preference, the internal layer of each external strand is wound in a helix in a direction of winding identical to the direction of winding of the intermediate layer of each external strand.

[0144] In a second embodiment of the cord, the intermediate layer of each external strand is wound around the internal layer of each external strand in a direction of winding opposite to the direction of winding of the cord.

[0145] In a first alternative form of this second embodiment, the intermediate layer of the internal strand is wound around the internal layer of the internal strand in a direction of winding identical to the direction of winding of the cord.

[0146] In a second alternative form of this second embodiment, the intermediate layer of the internal strand is wound around the internal layer of the internal strand in a direction of winding opposite to the direction of winding of the cord. In this particularly preferred second alternative form of the second embodiment of the cord, the rubbing-together of the threads of the adjacent layers and therefore the wearing thereof is limited.

[0147] In each of the first and second alternative forms of this second embodiment which have been described hereinabove, in the case that $Q > 1$, the internal layer of the internal strand is wound in a helix in a direction of winding identical to the direction of winding of

the cord or, as an alternative, in a direction of winding opposite to the direction of winding of the cord. As a preference, the internal layer of the internal strand is wound in a helix in a direction of winding identical to the direction of winding of the intermediate layer of the internal strand.

[0148] In each of the first and second alternative forms of this first embodiment which have been described hereinabove, the internal layer of each external strand is wound in a helix with a direction of winding identical to the direction of winding of the cord or, as an alternative, in a direction of winding opposite to the direction of winding of the cord. As a preference, the internal layer of each external strand is wound in a helix in a direction of winding identical to the direction of winding of the intermediate layer of each external strand.

[0149] Thus, in the context of the invention, in the case of an internal strand having 3 layers, it is possible to envisage the combinations of direction of winding that have been collated in Table B below, where ND signifies:

- in the case of an internal layer of the internal strand which layer is made up of a single thread, that the thread has no direction because its pitch is infinite, and
- in the case of an internal layer of the internal strand which layer is made up of several threads ($Q > 1$), that the direction of winding may just as well be S as Z:

Cord									
Internal strand	Direction for C1	ND	ND	ND	ND	ND	ND	ND	ND
	Direction for C2	S	Z	Z	S	S	Z	Z	S
	Direction for C3	Z	Z	S	S	Z	Z	S	S
External strand	Direction for C1'	S or Z	S or Z	S or Z	S or Z	S or Z	S or Z	S or Z	S or Z
	Direction for C2'	S	S	Z	Z	Z	Z	S	S
	Direction for C3'	Z	Z	S	S	Z	Z	S	S
Direction of winding of the cord		S	S	Z	Z	S	S	Z	Z

Table B

[0150] TYRE ACCORDING TO THE INVENTION

[0151] Another subject of the invention is a tyre comprising a cord as defined above.

[0152] The cord is most particularly intended for industrial vehicles selected from heavy vehicles such as "heavy-duty vehicles" – i.e. underground trains, buses, road haulage vehicles (lorries, tractors, trailers), off-road vehicles, agricultural vehicles or construction plant vehicles, or other transport or handling vehicles.

[0153] As a preference, the tyre is for a vehicle of the construction plant type. The layer has a size of the W R U type in which, as is known to those skilled in the art, W denotes: – the nominal aspect ratio H/B as defined by the ETRTO, when it is in the form H/B, H being the cross-sectional height of the tyre and B being the cross-sectional width of the tyre,

- H.00 or B.00 when it is in the form H.00 or B.00, in which H=B, H and B being as defined above,

U represents the diameter, in inches, of the rim seat on which the tyre is intended to be mounted, and R denotes the type of carcass reinforcement of the tyre, in this case radial. Examples of such dimensions are, for example, 40.00 R 57 or else 59/80 R 63.

[0154] Preferably, $U \geq 35$, more preferably $U \geq 49$ and even more preferably, $U \geq 57$.

[0155] In one embodiment, the tyre has a carcass reinforcement anchored in two beads and surmounted radially by a crown reinforcement which is itself surmounted by a tread, the crown reinforcement being joined to the said beads by two sidewalls, the carcass reinforcement comprising at least one cord as defined above.

[0156] In another embodiment, the tyre has a carcass reinforcement anchored in two beads and surmounted radially by a crown reinforcement which is itself surmounted by a tread, the crown reinforcement being joined to the said beads by two sidewalls, and comprising at least one cord as defined above.

[0157] Advantageously, the carcass reinforcement comprises at least one carcass ply comprising filamentary metal carcass reinforcing elements, each filamentary metal carcass reinforcing element making an angle of between 80° and 90° with the circumferential direction of the tyre.

[0158] Advantageously, the crown reinforcement comprises a working reinforcement comprising at least one cord as defined hereinabove.

[0159] Advantageously, the working reinforcement comprises at least one working ply comprising filamentary metal reinforcing elements arranged substantially parallel to one another, each filamentary metal working reinforcing element making an angle at most equal to 60° , preferably ranging from 15° to 40° with the circumferential direction of the tyre and being formed of a cord as defined hereinabove.

[0160] In one advantageous embodiment, the working reinforcement comprises at least a first and a second working ply, each first and second working ply respectively

comprising first and second filamentary metal working reinforcing elements arranged substantially parallel to one another in each first and second working ply, each filamentary metal working reinforcing element making an angle at most equal to 60° , preferably ranging from 15° to 40° with the circumferential direction of the tyre and being formed of a cord as defined hereinabove. Optionally, the first and second filamentary metal working reinforcing elements are crossed from one working ply to the other, which is to say that the orientation of the angle made by the first filamentary metal reinforcing elements with the circumferential direction of the tyre is the opposite to the orientation of the angle made by the second filamentary metal reinforcing elements with the circumferential direction of the tyre.

[0161] Advantageously, the crown reinforcement comprises a protective reinforcement comprising at least one protective ply comprising filamentary metal reinforcing elements arranged substantially parallel to one another, each filamentary metal protective reinforcing element making an angle at least equal to 10° , preferably ranging from 10° to 35° and preferentially from 15° to 30° with the circumferential direction of the tyre.

[0162] In one advantageous embodiment, the protective reinforcement comprises a first and a second protective ply, each first and second protective ply respectively comprising first and second filamentary metal protective elements arranged substantially parallel to one another in each first and second protective ply, each first and second filamentary metal protective reinforcing element making an angle at least equal to 10° , preferably ranging from 10° to 35° and preferentially from 15° to 30° with the circumferential direction of the tyre.

[0163] In a preferred embodiment, the protective reinforcement is interposed radially between the tread and the working reinforcement.

[0164] Advantageously, the crown reinforcement comprises an additional reinforcement comprising at least one additional ply comprising additional filamentary metal reinforcing elements arranged substantially parallel to one another in the additional ply, each filamentary metal reinforcing element making an angle at most equal to 10° , preferably ranging from 5° to 10° with the circumferential direction of the tyre.

[0165] In one advantageous embodiment, the additional reinforcement comprises a first and a second additional ply, each first and second additional ply respectively comprising first and second additional filamentary metal reinforcing elements arranged substantially parallel to one another in each first and second additional ply, each first and second additional filamentary metal reinforcing element making an angle at most equal to 10° , preferably ranging from 5° to 10° with the circumferential direction of the tyre.

Brief Description of the Drawings

[0166] The invention will be understood better from reading the following description, which is given solely by way of non-limiting example and with reference to the drawings, in which:

- Figure 1 is a view in cross section perpendicular to the circumferential direction of a tyre according to the invention;
- Figure 2 is a detail view of the region II of Figure 1;
- Figures 3, 4 and 5 are schematic views in section perpendicular to the axis of the cord (which is assumed to be straight and at rest) of cords according to first, second and third embodiments of the invention, respectively;
- Figures 6, 7 and 8 are views similar to those of Figures 3, 4 and 5 of cords according to fourth, fifth and sixth embodiments of the invention, respectively;
- Figures 9, 10 and 11 are views similar to those of Figures 3, 4 and 5 of cords according to seventh, eighth and ninth embodiments of the invention, respectively;
- Figures 12, 13 and 14 are views similar to those of Figures 3, 4 and 5 of cords according to tenth, eleventh and twelfth embodiments of the invention, respectively;
- Figures 15 and 16 are views similar to those of Figures 3 and 4 of cords according to thirteenth and fourteenth embodiments of the invention, respectively;
- Figures 17, 18 and 19 are views similar to those of Figures 3, 4 and 5 of cords according to fifteenth, sixteenth and seventeenth embodiments of the invention, respectively;
- Figures 20, 21 and 22 are views similar to those of Figures 3, 4 and 5 of cords according to eighteenth, nineteenth and twentieth embodiments of the invention, respectively;
- Figure 23 is a schematic view in projection onto a plane containing the axis of an external strand prior to assembly of the cord according to the first embodiment of the invention; and
- Figure 24 is a detailed view of the region XXIV depicting a radial passage window delimited by threads of an intermediate layer and threads of an external layer of the external strand of Figure 23.

[0167] Any range of values denoted by the expression “between a and b” represents the range of values extending from more than a to less than b (namely excluding the end-points a and b), whereas any range of values denoted by the expression “from a to b” means the range of values extending from the end-point “a” as far as the end-point “b”, namely including the strict end-points “a” and “b”.

Detailed Description of Specific Embodiments**[0168] EXAMPLE OF A TYRE ACCORDING TO THE INVENTION**

[0169] A frame of reference X, Y, Z corresponding to the usual respectively axial (X), radial (Y) and circumferential (Z) orientations of a tyre has been depicted in the figures.

[0170] The “median circumferential plane” M of the tyre is the plane which is normal to the axis of rotation of the tyre and which is situated equidistant from the annular reinforcing structures of each bead, and passes through the middle of the crown reinforcement.

[0171] Figures 1 and 2 depict a tyre according to the invention and denoted by the general reference 10.

[0172] The tyre 10 is for a heavy vehicle of construction plant type, for example of “dumper” type. Thus, the tyre 10 has a dimension of the type 53/80R63.

[0173] The tyre 10 has a crown 12 reinforced by a crown reinforcement 14, two sidewalls 16 and two beads 18, each of these beads 18 being reinforced with an annular structure, in this instance a bead thread 20. The crown reinforcement 14 is surmounted radially by a tread 22 and connected to the beads 18 by the sidewalls 16. A carcass reinforcement 24 is anchored in the two beads 18 and in this instance wound around the two bead threads 20 and comprises a turnup 26 positioned towards the outside of the tyre 20, which is shown here fitted onto a wheel rim 28. The carcass reinforcement 24 is surmounted radially by the crown reinforcement 14.

[0174] The carcass reinforcement 24 comprises at least one carcass ply 30 comprising filamentary metal carcass reinforcing elements 31 and extending from one bead 18 to the other so as to form an angle of between 80° and 90° with the circumferential direction Z of the tyre 10.

[0175] The tyre 10 also comprises a sealing ply 32 made up of an elastomer (commonly known as “inner liner”) which defines the radially internal face 34 of the tyre 10 and which is intended to protect the carcass ply 30 from the diffusion of air coming from the space inside the tyre 10.

[0176] The crown reinforcement 14 comprises, radially from the outside towards the inside of the tyre 10, a protective reinforcement 36 arranged radially on the inside of the tread 22, a working reinforcement 38 arranged radially on the inside of the protective reinforcement 36 and an additional reinforcement 80 arranged radially on the inside of the working reinforcement 38. The protective reinforcement 36 is thus interposed radially between the tread 22 and the working reinforcement 38. The working reinforcement 38 is interposed radially between the protective reinforcement 36 and the additional reinforcement 80.

[0177] The protective reinforcement 36 comprises first and second protective plies 42,

44, the first ply 42 being arranged radially on the inside of the second ply 44. Each first and second protective ply 42, 44 respectively comprises first and second filamentary metal protective reinforcing elements 43, 45 arranged substantially parallel to one another in each first and second protective ply 42, 44. Each first and second filamentary metal protective reinforcing element 43, 45 makes an angle at least equal to 10° , preferably in the range from 10° to 35° and more preferably from 15° to 30° , with the circumferential direction Z of the tyre.

[0178] The working reinforcement 38 comprises first and second working plies 46, 48, the first ply 46 being arranged radially on the inside of the second ply 48. Each first and second working ply 46, 48 respectively comprises first and second filamentary metal working reinforcing elements 47, 49 arranged substantially parallel to one another in each first and second working ply 46, 48. Each first and second filamentary metal working reinforcing element 47, 49 makes an angle at most equal to 60° , preferably in the range from 15° to 40° , with the circumferential direction Z of the tyre 10. Optionally, the first and second filamentary metal working reinforcing elements 47, 49 are crossed from one working ply to the other, which is to say that the orientation of the angle made by the first filamentary metal reinforcing elements 47 with the circumferential direction Z of the tyre 10 is the opposite to the orientation of the angle made by the second filamentary metal reinforcing elements 49 with the circumferential direction Z of the tyre 10.

[0179] The additional reinforcement 80, also referred as the limiting block, the function of which is to at least partially react the mechanical stresses of inflation, comprises first and second additional plies 82, 84, each first and second additional ply 82, 84 respectively comprising first and second additional filamentary metal reinforcing elements 83, 85 arranged substantially parallel to one another in each first and second additional ply 82, 84. Each first and second additional filamentary metal reinforcing element 83, 85 makes an angle at most equal to 10° , preferably in the range from 5° to 10° , with the circumferential direction Z of the tyre 10. The additional filamentary metal reinforcing elements are, for example, as described in FR 2 419 181 or FR 2 419 182.

[0180] In one embodiment, each first and second filamentary metal reinforcing element 47, 49 is formed by a cord according to the invention, for example the cord 50 described hereinbelow.

[0181] In another embodiment, each filamentary metal carcass reinforcing element 31 is formed by a cord according to the invention, for example the cord 50 described hereinbelow.

[0182] In yet another embodiment, each first and second filamentary metal reinforcing element 47, 49 and each filamentary metal carcass reinforcing element 31 is formed by

a cord according to the invention, it being possible for these cords to be identical or different according to whether they are filamentary metal reinforcing elements 31, 47 or 49.

[0183] CORD ACCORDING TO A FIRST EMBODIMENT OF THE INVENTION

[0184] Figure 3 depicts the cord 50 according to a first embodiment of the invention.

[0185] The cord 50 is metal and of the multi-strand type with two cylindrical layers. Thus, it will be understood that there are two layers, not more, not less, of strands of which the cord 50 is made. The layers of strands are adjacent and concentric. The cord 50 is devoid of polymer compound and of elastomer compound when it is not integrated into the tyre.

[0186] The cord 50 comprises an internal layer CI of the cord 50, and an external layer CE of the cord 50. The internal layer CI is made up of a single internal strand TI. The external layer CE is made up of $L > 1$ external strands, which means to say of a plurality of external strands TE. In this instance, $L = 6, 7, 8, 9$ or 10 , for preference $L = 6, 7$ or 8 and in this instance $L = 6$.

[0187] The cord 50 also comprises a wrapper F made up of a single wrapping thread.

[0188] The internal strand TI has an infinite pitch.

[0189] The external layer CE is wound around the internal layer CI in a direction of winding of the cord, in this instance the S-direction. The external strands TE are wound in a helix around the internal strand TI with a pitch p such that $40 \text{ mm} \leq p \leq 100 \text{ mm}$ and, for preference, $50 \text{ mm} \leq p \leq 90 \text{ mm}$. Here, $p = 70 \text{ mm}$.

[0190] The wrapper F is wound around the external layer CE in a direction of winding of the wrapper, in this instance in the opposite to the direction of winding of the cord, in this instance the Z-direction. The wrapping thread is wound in a helix around the external strands TE with a pitch p_f such that $2 \text{ mm} \leq p_f \leq 10 \text{ mm}$ and, for preference, $3 \text{ mm} \leq p_f \leq 8 \text{ mm}$. Here, $p_f = 5.1 \text{ mm}$.

[0191] The assembly made up of the internal CI and external CE layers, which means to say the cord 50 without the wrapper F, has a diameter D greater than or equal to 4 mm , and less than or equal to 6 mm , preferably less than or equal to 5.5 mm , and more preferably less than or equal to 5.0 mm . Here, $D = 4.90 \text{ mm}$.

[0192] The external layer CE of the cord 50 is desaturated. The mean inter-strand distance E separating two adjacent external strands TE is greater than or equal to $30 \text{ }\mu\text{m}$, preferably greater than or equal to $70 \text{ }\mu\text{m}$, more preferably greater than or equal to $100 \text{ }\mu\text{m}$, more preferably still, greater than or equal to $150 \text{ }\mu\text{m}$, highly preferably, greater than or equal to $200 \text{ }\mu\text{m}$. In this embodiment, the inter-strand distance of the external layer of external strands is greater than or equal to $70 \text{ }\mu\text{m}$. Here, $E = 98 \text{ }\mu\text{m}$.

[0193] The internal strand TI has a diameter D_I and each external strand TE has a

diameter DE which are such that the ratio $DI/DE > 1$, for preference $DI/DE \geq 1.05$ and more preferably $DI/DE \geq 1.10$. This ratio DI/DE is also such that $DI/DE \leq 1.40$, for preference $DI/DE \leq 1.35$ and more preferably $DI/DE \leq 1.30$. In this case, $DI = 1.78$ mm, $DE = 1.56$ mm and $DI/DE = 1.14$.

[0194] The external layer CE of the cord 50 is incompletely unsaturated. Specifically, $SIE = 6 \times 0.098 = 0.59$ mm, which is a value lower than $DE = 1.56$ mm.

[0195] Internal strand TI of the cord 50

[0196] The internal strand TI has at least two layers. In this instance, the internal strand TI has three layers. The internal strand TI comprises, in this instance is made up of, three layers, not more, not less.

[0197] The internal strand TI comprises an internal layer C1 made up of Q internal thread(s) F1, an intermediate layer C2 made up of M intermediate threads F2 wound in a helix around the internal layer C1, and an external layer C3 made up of N external threads F3 wound in a helix around the internal layer C1 and around and in contact with the intermediate layer C2.

[0198] $Q = 1, 2, 3$ or 4 and more preferably here, $Q = 1$.

[0199] Where $Q = 1$, $M = 5$ or 6 and $N = 10, 11$ or 12, for preference $Q = 1$, $M = 5$ or 6 and $N = 10$ or 11 and here $Q = 1$, $M = 6$ and $N = 11$.

[0200] The internal thread F1 has an infinite pitch.

[0201] The intermediate layer C2 of the internal strand TI is wound around the internal layer C1 of the internal strand TI in an internal strand intermediate layer direction of winding, in this instance in the direction Z that is the opposite to the direction of winding of the cord, S. The M intermediate wires F2 are wound in a helix around the internal wire F1 with a pitch p_2 such that $8 \text{ mm} \leq p_2 \leq 20 \text{ mm}$, for preference, $9 \text{ mm} \leq p_2 \leq 18 \text{ mm}$, and more preferably $10 \text{ mm} \leq p_2 \leq 16 \text{ mm}$. Here, $p_2 = 14$ mm.

[0202] The external layer C3 of the internal strand TI is wound around the internal C1 and intermediate C2 layers of the internal strand TI in an internal strand external layer direction of winding, in this instance in the direction Z that is the opposite to the direction of winding of the cord S and in the same direction Z as the intermediate layer C2 of the internal strand TI. The N external threads F3 are wound in a helix around the M intermediate threads F2 with a pitch p_3 such that $10 \text{ mm} \leq p_3 \leq 40 \text{ mm}$, for preference $12 \text{ mm} \leq p_3 \leq 30 \text{ mm}$, and more preferably $15 \text{ mm} \leq p_3 \leq 25 \text{ mm}$. Here $p_3 = 20$ mm.

[0203] Because p_1 is different from p_2 and p_2 is different from p_3 , the internal strand has layers which are cylindrical.

[0204] The intermediate layer C2 of the internal strand TI is desaturated and incompletely unsaturated. The inter-thread distance I_2 of the intermediate layer C2 which

on average separates the M intermediate threads is greater than or equal to 5 μm and is here equal to 11.6 μm . Because the intermediate layer C2 is incompletely unsaturated, the sum SI2 of the inter-thread distances I2 of the intermediate layer C2 is less than the diameter d2 of the intermediate threads F2 of the intermediate layer C2. Here, the sum $\text{SI2}=6 \times 0.0116 = 0.07 \text{ mm}$, which is a value strictly less than $d2 = 0.35 \text{ mm}$.

[0205] The sum SI2 of the inter-thread distances I2 of the intermediate layer C2 is less than the diameter d3 of the external threads F3 of the external layer C3 and preferably less than or equal to $0.8 \times d3$. Here, the sum $\text{SI2}=6 \times 0.0116 = 0.07 \text{ mm}$, which is a value strictly less than $d3 = 0.35 \text{ mm}$.

[0206] The external layer C3 of the internal strand TI is desaturated and completely unsaturated. The inter-thread distance I3 of the external layer C3 which on average separates the N external threads is advantageously greater than or equal to 5 μm , preferably greater than or equal to 15 μm , more preferably greater than or equal to 35 μm , and is here equal to 45 μm . The sum SI3 of the inter-thread distances I3 of the external layer C3 is greater than the diameter d3 of the external threads F3 of the external layer C3. Here, the sum $\text{SI3}=11 \times 0.045 = 0.50 \text{ mm}$, which is a value strictly greater than $d3 = 0.35 \text{ mm}$.

[0207] Each internal, intermediate and external thread of the internal strand TI respectively has a diameter d1, d2 and d3. Each internal thread diameter d1, intermediate thread diameter d2 and external thread diameter d3 of the internal strand TI ranges from 0.15 mm to 0.60 mm, preferably from 0.20 mm to 0.50 mm, more preferably from 0.22 mm to 0.40 mm, and more preferably still from 0.24 mm to 0.35 mm.

[0208] The internal thread F1 of the internal strand TI has a diameter d1 greater than or equal to the diameter d2 of each intermediate thread F2 of the internal strand TI, and highly preferably, $1 \leq d1/d2 \leq 1.10$. The internal thread F1 of the internal strand TI has a diameter d1 greater than or equal to the diameter d3 of each external thread F3 of the internal strand TI, and highly preferably, $1 \leq d1/d3 \leq 1.10$. Each diameter d2 of each intermediate thread F2 of the internal strand TI and each diameter d3 of each external thread F3 of the internal strand TI are such that $d2=d3$.

[0209] In this instance, $d1 > d2$ and $d1 > d3$ and $d1=0.38 \text{ mm}$, $d2=d3=0.35 \text{ mm}$.

[0210] External strands TE of the cord 50

[0211] Each external strand TE has three layers. Thus, each external strand TE comprises, in this instance is made up of, three layers, not more, not less.

[0212] Each external strand TE comprises an internal layer C1' made up of $Q'=2, 3 \text{ or } 4$ internal threads, an intermediate layer C2' made up of M' intermediate threads F2' wound in a helix around the internal layer C1', and an external layer C3' made up of N' external

threads F3' wound in a helix around the internal layer C1' and around and in contact with the intermediate layer C2'.

[0213] $M'=7, 8, 9$ or 10 , $N'=12, 13, 14$ or 15 and here $Q'=2$, $M'=7$ or 8 and $N'=12$ or 13 . In this instance, the cord 50 is such that $Q'=2$, $M'=7$ and $N'=12$.

[0214] The internal layer C1' of each external strand TE is wound in a helix in a direction of winding for an internal layer of each external strand, in this instance in the direction Z that is opposite to the direction of winding S of the cord. The Q' internal threads F1' are wound in a helix with a pitch $p1'$ such that $3 \text{ mm} \leq p1' \leq 16 \text{ mm}$, for preference $4 \text{ mm} \leq p1' \leq 13 \text{ mm}$, and more preferably still $15 \text{ mm} \leq p1' \leq 10 \text{ mm}$. Here $p1'=6 \text{ mm}$.

[0215] The intermediate layer C2' of each external strand TE is wound around the internal layer C1' of each external strand TE in a direction of winding for an intermediate layer of each external strand, in this instance in the direction Z that is opposite to the direction of winding S of the cord. The M' intermediate threads F2' are wound in a helix around the internal threads F1' with a pitch $p2'$ such that $8 \text{ mm} \leq p2' \leq 20 \text{ mm}$, for preference $9 \text{ mm} \leq p2' \leq 18 \text{ mm}$, and more preferably, $10 \text{ mm} \leq p2' \leq 16 \text{ mm}$. Here $p2'=11 \text{ mm}$.

[0216] The external layer C3' of each external strand TE is wound around the intermediate layer C2' of each external strand TE in a direction of winding for an external layer of each external strand, in this instance in the direction Z that is the opposite of the direction of winding S of the cord and in the same direction Z as the internal layer C1' and intermediate layer C2' of each external strand TE and in the same direction Z as the external layer C3 of the internal strand TI. The N' external threads F3' are wound in a helix around the M' intermediate threads F2' with a pitch $p3'$ such that $10 \text{ mm} \leq p3' \leq 40 \text{ mm}$, for preference $12 \text{ mm} \leq p3' \leq 30 \text{ mm}$, and more preferably $15 \text{ mm} \leq p3' \leq 25 \text{ mm}$. Here $p3'=18 \text{ mm}$.

[0217] The pitches $p2'$ and $p3'$ satisfy $0.33 \leq (p3'-p2')/p3' \leq 0.45$.

[0218] $0.36 \leq (p3'-p2')/p3'$, preferably $0.38 \leq (p3'-p2')/p3'$.

[0219] $(p3'-p2')/p3' \leq 0.42$ and for preference $(p3'-p2')/p3' \leq 0.40$.

[0220] In this instance $(p3'-p2')/p3'=0.39$.

[0221] Because $p1'$ is different from $p2'$ and $p2'$ is different from $p3'$, the external strand has layers which are cylindrical.

[0222] The intermediate layer C2' of each external strand TE is desaturated and, in this instance, completely unsaturated. The inter-thread distance $l2'$ of the intermediate layer C2' which on average separates the M' intermediate threads is advantageously greater than or equal to $5 \mu\text{m}$, preferably greater than or equal to $15 \mu\text{m}$, more preferably greater than or equal to $35 \mu\text{m}$, and more preferably still, than/to $50 \mu\text{m}$, and in this embodiment, the inter-thread distance $l2'$ is very preferably greater than or equal to $60 \mu\text{m}$, and is here

equal to 75 μm . Because the intermediate layer C2' is completely unsaturated, the sum $SI2'$ of the inter-thread distances $I2'$ of the intermediate layer C2' is less than the diameter $d2'$ of the intermediate threads F2' of the intermediate layer C2'. Here, the sum $SI2'=7 \times 0.075 = 0.52 \text{ mm}$, which is a value strictly greater than $d2' = 0.26 \text{ mm}$.

[0223] The external layer C3' of each external strand TE is desaturated and completely unsaturated. The inter-thread distance $I3'$ of the external layer C3' which on average separates the N' external threads is advantageously greater than or equal to 5 μm , preferably greater than or equal to 15 μm , more preferably greater than or equal to 35 μm , and more preferably still, than/to 50 μm , and in this embodiment, the inter-thread distance $I2'$ is very preferably greater than or equal to 60 μm , and is here equal to 71 μm . The sum $SI3'$ of the inter-thread distances $I3'$ of the external layer C3' is greater than the diameter $d3'$ of the external threads F3' of the external layer C3'. Here, the sum $SI3'=12 \times 0.071 = 0.85 \text{ mm}$, which is a value strictly greater than $d3' = 0.26 \text{ mm}$.

[0224] Each internal, intermediate and external thread of each external strand TE respectively has a diameter $d1'$, $d2'$ and $d3'$. Each internal thread diameter $d1'$, intermediate thread diameter $d2'$ and external thread diameter $d3'$ of each external strand TE ranges from 0.15 mm to 0.60 mm, preferably from 0.20 mm to 0.50 mm, more preferably from 0.22 mm to 0.40 mm, and more preferably still, from 0.24 mm to 0.35 mm.

[0225] The internal thread F1' of each external strand TE has a diameter $d1'$ greater than or equal to the diameter $d2'$ of each intermediate thread F2' of each external strand TE, and very preferably, $1 \leq d1'/d2' \leq 1.10$. The internal thread F1' of each external strand TE has a diameter $d1'$ greater than or equal to the diameter $d3'$ of each external thread F3' of each external strand TE, and very preferably, $1 \leq d1'/d3' \leq 1.10$. Each diameter $d2'$ of each intermediate thread F2' of each external strand TE and each diameter $d3'$ of each external thread F3' of each external strand TE are such that $d2'=d3'$.

[0226] In this particular instance, $d1'=d2'=d3'$ and $d1'=d2'=d3'=0.26 \text{ mm}$.

[0227] Each external thread F3 of the internal strand TI has a diameter $d3$ greater than or equal to the diameter $d3'$ of each external thread F3 of each external strand TE. For preference here $d3=0.35 \text{ mm} > d3'=0.26 \text{ mm}$. For preference, $1 < d3/d3' \leq 2$, more preferably $1 < d3/d3' \leq 1.5$ and more preferably still, $1.25 < d3/d3' \leq 1.5$, and here $d3/d3'=1.34$.

[0228] Each thread has a breaking strength, denoted R_m , such that $2500 \leq R_m \leq 3100 \text{ MPa}$. The steel for these threads is said to be of SHT ("Super High Tensile") grade. Other threads may be used, for example threads of an inferior grade, for example of NT ("Normal Tensile") or HT ("High Tensile") grade, just as may threads of a superior grade, for example of UT ("Ultra Tensile") or MT ("Mega Tensile") grade.

[0229] METHOD FOR MANUFACTURING THE CORD ACCORDING TO THE INVENTION

[0230] The cord according to the invention is manufactured using a method comprising steps well known to those skilled in the art.

[0231] The aforementioned internal strand is manufactured according to known methods involving the following steps, preferably performed in line and continuously:

- first of all, in instances in which $Q > 1$, a first step of assembling, by cabling, the Q internal threads $F1$ of the internal layer $C1$ at the pitch $p1$ and in the Z -direction to form the internal layer $C1$ at a first assembling point; in embodiments in which $Q = 1$, the first assembling step is omitted;
- followed by a second step of assembling, by cabling or by twisting, the M intermediate threads $F2$ around the Q internal threads $F1$ of the internal layer $C1$ at the pitch $p2$ and in the Z -direction to form the intermediate layer $C2$ at a second assembling point;
- followed by a third step of assembling, by cabling or by twisting, the N external threads $F3$ around the M intermediate threads $F2$ of the intermediate layer $C2$ at the pitch $p3$ and in the Z -direction to form the external layer $C3$ and each internal strand TI at a third assembling point;
- preferably a final twist-balancing step.

[0232] In a step for manufacturing the external strands using the following steps, preferably carried out in line and continuously:

- first of all, a first step of assembling, by cabling, the Q internal threads $F1$ of the internal layer $C1$ at the pitch $p1$ and in the Z -direction to form the internal layer $C1$ at a first assembling point;
- followed by a second step of assembling, by cabling or by twisting, the M' intermediate threads $F2'$ around the Q' internal threads $F1'$ of the internal layer $C1'$ at the pitch $p2'$ and in the Z -direction to form the intermediate layer $C2'$ at a first assembling point;
- followed by a third step of assembling, by cabling or by twisting, the N' external threads $F3'$ around the M' intermediate threads $F2'$ of the intermediate layer $C2'$ at the pitch $p3'$ and in the Z -direction to form the external layer $C3'$ and each external strand TE at a second assembling point;
- preferably a final twist-balancing step.

[0233] What is meant here by “twist balancing” is, as is well known to those skilled in the art, the cancellation of the residual torque pairs (or the elastic return of the twist) applied to each thread of the strand, in the intermediate layer as in the external layer.

[0234] After this final twist-balancing step, the manufacture of the strand is complete. Each strand is wound onto one or more receiving reels, for storage, prior to the later operation of assembling the elementary strands by cabling in order to obtain the multi-strand cord.

[0235] Thus, the L external strands TE are assembled around the internal strand TI at the pitch p and in the S-direction to form the cord 50. Possibly, in a last assembly step, the wrapper F is wound, at the pitch pf and in the Z-direction, around the assembly previously obtained.

[0236] The cord is then incorporated by skimming into composite fabrics formed from a known composition based on natural rubber and carbon black as reinforcing filler, conventionally used for manufacturing crown reinforcements of radial tyres. This compound essentially contains, in addition to the elastomer and the reinforcing filler (carbon black), an antioxidant, stearic acid, an extender oil, cobalt naphthenate as adhesion promoter, and finally a vulcanization system (sulfur, accelerator and ZnO).

[0237] The composite fabrics reinforced by these cords have an elastomer compound matrix formed from two thin layers of elastomer compound which are superposed on either side of the cords and which have a thickness of between 1 and 4 mm, inclusive, respectively. The skim-coating pitch (the pitch at which the cords are laid in the elastomer compound fabric) ranges from 4 mm to 8 mm.

[0238] These composite fabrics are then used as working ply in the crown reinforcement during the method of manufacturing the tyre, the steps of which are otherwise known to a person skilled in the art.

[0239] CORD ACCORDING TO A SECOND EMBODIMENT OF THE INVENTION

[0240] Figure 4 depicts a cord 51 according to a second embodiment of the invention. Elements similar to those of the first embodiment are denoted by identical references.

[0241] Unlike in the first embodiment described hereinabove, the cord 51 according to the second embodiment is such that $Q'=3$, $M'=8$ or 9 and $N'=13$ or 14 , and here such that $Q'=3$, $M'=8$ and $N'=13$.

[0242] According to the invention, in instances in which $Q'=3$, $0.35 \leq (p3'-p2')/p3' \leq 0.42$.

[0243] Advantageously $0.36 \leq (p3'-p2')/p3'$, preferably $0.38 \leq (p3'-p2')/p3'$. Advantageously also $(p3'-p2')/p3' \leq 0.40$. In this particular instance, as in the first embodiment, $(p3-p2)/p3=0.39$.

[0244] CORD ACCORDING TO A THIRD EMBODIMENT OF THE INVENTION

[0245] Figure 5 depicts a cord 52 according to a third embodiment of the invention. Elements similar to those of the first embodiment are denoted by identical references.

[0246] Unlike in the first embodiment of the cord 50 described hereinabove, the cord 52 according to the third embodiment is such that $Q'=4$, $M'=9$ or 10 and $N'=14$ or 15 , and here such that $Q'=4$, $M'=9$ and $N'=14$.

[0247] According to the invention, in instances in which $Q'=4$, $0.28 \leq (p_3'-p_2')/p_3' \leq 0.43$.

[0248] Advantageously $0.32 \leq (p_3'-p_2')/p_3'$, preferably $0.36 \leq (p_3'-p_2')/p_3'$. Advantageously also $(p_3'-p_2')/p_3' \leq 0.40$. In this particular instance, as in the first embodiment, $(p_3-p_2)/p_3=0.39$. It would also have been possible to envisage a cord in which, for preference, $(p_3-p_2)/p_3 \leq 0.38$.

[0249] CORDS ACCORDING TO THE FOURTH TO TWENTIETH EMBODIMENTS OF THE INVENTION

[0250] Figures 6 to 22 depict the cords 53 to 69 according to the fourth to twentieth embodiments of the invention respectively.

[0251] The features of the various cords 50 to 69 according to the various embodiments of the invention have been summarized in Tables 1 to 5 hereinbelow.

Cord		50	51	52	53	54	55
TI	Q/M/N	1/6/11	1/6/11	1/6/11	3/9/15	3/9/15	3/9/15
	d1/d2/d3	0.38/0.35/0.35	0.38/0.35/0.35	0.38/0.35/0.35	0.40/0.38/0.38	0.40/0.38/0.38	0.40/0.38/0.38
	direction for C1/pitch p1 (mm)	-/Inf	-/Inf	-/Inf	Z/6	Z/6	Z/6
	direction for C2/pitch p2 (mm)	Z/14	Z/14	Z/14	Z/11	Z/11	Z/11
	direction for C3/pitch p3 (mm)	Z/20	Z/20	Z/20	Z/18	Z/18	Z/18
	(p3-p2)/p3	0.30	0.30	0.30	0.39	0.39	0.39
	I2 (μm)/SI2 (mm)	12/0.07	12/0.07	12/0.07	25/0.23	25/0.23	25/0.23
	I3 (μm)/SI3 (mm)	45/0.50	45/0.50	45/0.50	15/0.23	15/0.23	15/0.23
	DI (mm)	1.78	1.78	1.78	2.39	2.39	2.39
TE	Q'/M'/N'	2/7/12	3/8/13	4/9/14	2/7/12	3/8/13	4/9/14
	d1'/d2'/d3'	0.26/0.26/0.26	0.26/0.26/0.26	0.26/0.26/0.26	0.26/0.26/0.26	0.26/0.26/0.26	0.26/0.26/0.26
	direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
	direction for C2'/pitch p2' (mm)	Z/11	Z/11	Z/11	Z/11	Z/11	Z/11
	direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
	(p3'-p2')/p3'	0.39	0.39	0.39	0.39	0.39	0.39
	I2' (μm)/SI2' (mm)	75/0.52	49/0.39	38/0.34	75/0.52	49/0.39	38/0.34
	I3' (μm)/SI3' (mm)	71/0.85	55/0.71	47/0.66	71/0.85	55/0.71	47/0.66
	DE (mm)	1.56	1.60	1.67	1.56	1.60	1.67

L	6	6	6	6	6	6
D (mm)	4.90	4.98	5.12	5.51	5.59	5.73
E (μm)	98	76	40	404	382	344
DI/DE	1.14	1.11	1.07	1.53	1.49	1.43
Direction of winding of the cord	S	S	S	S	S	S

Table 1

Cord		56	57	58	59	60	61
TI	Q/M/N	1/6/11	1/6/11	1/6/11	3/9/15	3/9/15	3/9/15
	d1/d2/d3	0.60/0.50/0.45	0.60/0.50/0.45	0.60/0.50/0.45	0.40/0.38/0.38	0.40/0.38/0.38	0.40/0.38/0.38
	direction for C1/pitch p1 (mm)	-/Inf	-/Inf	-/Inf	Z/6	Z/6	Z/6
	direction for C2/pitch p2 (mm)	Z/14	Z/14	Z/14	Z/11	Z/11	Z/11
	direction for C3/pitch p3 (mm)	Z/20	Z/20	Z/20	Z/18	Z/18	Z/18
	(p3-p2)/p3	0.30	0.30	0.30	0.39	0.39	0.39
	I2 (μm)/SI2 (mm)	39/0.23	39/0.23	39/0.23	25/0.23	25/0.23	25/0.23
	I3 (μm)/SI3 (mm)	107/1.18	107/1.18	107/1.18	15/0.23	15/0.23	15/0.23
	DI (mm)	2.5	2.5	2.5	2.39	2.39	2.39
TE	Q'/M'/N'	2/7/12	3/8/13	4/9/14	2/7/12	3/8/13	4/9/14
	d1'/d2'/d3'	0.32/0.30/0.30	0.32/0.30/0.30	0.32/0.30/0.30	0.35/0.32/0.32	0.35/0.32/0.32	0.35/0.32/0.32
	direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
	direction for C2'/pitch	Z/11	Z/11	Z/11	Z/11	Z/11	Z/11

	p2' (mm)						
	direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
	(p3'-p2')/p3'	0.39	0.39	0.39	0.39	0.39	0.39
	I2' (μm)/SI2' (mm)	101/0.70	70/0.56	57/0.51	114/0.80	80/0.64	66/0.59
	I3' (μm)/SI3' (mm)	89/1.07	70/0.92	62/0.87	98/1.18	78/1.01	69/0.97
	DE (mm)	1.84	1.89	1.98	1.98	2.04	2.13
	L	6	6	6	6	6	6
	D (mm)	6.18	6.28	6.46	6.35	6.46	6.65
	E (μm)	310	282	234	176	146	94
	DI/DE	1.36	1.32	1.26	1.21	1.17	1.12
	Direction of winding of the cord	S	S	S	S	S	S

Table 2

Cord		62	63
TI	Q/-/N	2/-/7	1/-/7
	d1/-/d3	0.45/-/0.45	0.45/-/0.45
	direction for C1/pitch p1 (mm)	Z/7.7	Z/7.7
	direction for C2/pitch p2 (mm)	-/-	-/-
	direction for C3/pitch p3 (mm)	Z/15.4	Z/15.4
	I3 (μm)/SI3 (mm)	124/0.87	124/0.87

	DI (mm)	1.80	1.80
TE	Q'/M'/N'	2/7/12	3/8/13
	d1'/d2'/d3'	0.28/0.26/0.26	0.28/0.26/0.26
	direction for C1'/pitch p1' (mm)	Z/6	Z/6
	direction for C2'/pitch p2' (mm)	Z/11	Z/11
	direction for C3'/pitch p3' (mm)	Z/18	Z/18
	(p3'-p2')/p3'	0.39	0.39
	I2' (µm)/SI2' (mm)	92/0.64	65/0.52
	I3' (µm)/SI3' (mm)	81/0.97	65/0.85
	DE (mm)	1.60	1.64
	L	6	6
	D (mm)	5.00	5.08
	E (µm)	87	63
	DI/DE	1.13	1.09
	Direction of winding of the cord	S	S

Table 3

Cord		64	65	66
TI	Q/-/N	3/-/8	3/-/8	3/-/8
	d1/-/d3	0.45/-/0.45	0.45/-/0.45	0.45/-/0.45
	direction for C1/pitch p1	Z/7.7	Z/7.7	Z/7.7

	(mm)			
	direction for C2/pitch p2 (mm)	-/-	-/-	-/-
	direction for C3/pitch p3 (mm)	Z/15.4	Z/15.4	Z/15.4
	I3 (µm)/SI3 (mm)	79/0.63	79/0.63	79/0.63
	DI (mm)	1.87	1.87	1.87
TE	Q'/M'/N'	2/7/12	3/8/13	4/9/14
	d1'/d2'/d3'	0.28/0.26/0.26	0.28/0.26/0.26	0.28/0.26/0.26
	direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6
	direction for C2'/pitch p2' (mm)	Z/11	Z/11	Z/11
	direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18
	(p3'-p2')/p3'	0.39	0.39	0.39
	I2' (µm)/SI2' (mm)	92/0.64	65/0.52	54/0.49
	I3' (µm)/SI3' (mm)	81/0.97	65/0.85	57/0.80
	DE (mm)	1.60	1.64	1.72
L		6	6	6
D (mm)		5.08	5.16	5.31
E (µm)		123	100	60
DI/DE		1.17	1.14	1.09
Direction of winding of the cord		S	S	S

Table 4

Cord		67	68	69
TI	Q/-/N	4/-/9	4/-/9	4/-/9
	d1/-/d3	0.45/-/0.45	0.45/-/0.45	0.45/-/0.45
	direction for C1/pitch p1 (mm)	Z/7.7	Z/7.7	Z/7.7
	direction for C2/pitch p2 (mm)	-/-	-/-	-/-
	direction for C3/pitch p3 (mm)	Z/15.4	Z/15.4	Z/15.4
	I3 (μm)/SI3 (mm)	60/0.54	60/0.54	60/0.54
	DI (mm)	2.00	2.00	2.00
TE	Q'/M'/N'	2/7/12	3/8/13	4/9/14
	d1'/d2'/d3'	0.28/0.26/0.26	0.28/0.26/0.26	0.28/0.26/0.26
	direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6
	direction for C2'/pitch p2' (mm)	Z/11	Z/11	Z/11
	direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18
	(p3'-p2')/p3'	0.39	0.39	0.39
	I2' (μm)/SI2' (mm)	92/0.64	65/0.52	54/0.49
	I3' (μm)/SI3' (mm)	81/0.97	65/0.85	57/0.80
	DE (mm)	1.60	1.64	1.72
L		6	6	6

D (mm)	5.20	529	5.44
E (µm)	186	162	122
DI/DE	1.25	1.21	1.16
Direction of winding of the cord	S	S	S

Table 5

[0252] COMPARATIVE TESTS AND MEASUREMENTS**[0253] Cord permeability test**

[0254] Such a permeability test is well known to those skilled in the art and makes it possible to determine the longitudinal permeability to air of the cords tested, by measuring the volume of air passing along a test specimen under constant pressure over a given period of time. The principle of such a test, which is well known to those skilled in the art, is to demonstrate the effectiveness of the treatment of a cord to make it impermeable to air; it has been described for example in standard ASTM D2692-98.

[0255] Such a test is carried out on as-manufactured and non-aged cords. The raw cords are coated on the outside beforehand with an elastomer compound referred to as coating compound. For this purpose, a series of 10 cords laid parallel (distance between cords: 20 mm) is placed between two layers or "skims" (two rectangles measuring 80 x 200 mm) of a diene elastomer compound in the raw state, each skim having a thickness of 5 mm; all of this is then immobilized in a mould, with each of the cords being kept under sufficient tension (for example 3 daN) to guarantee that it lies straight as it is being placed in the mould, using clamping modules; it is then vulcanized (cured) for around 10 to 12 hours at a temperature of around 120°C and at a pressure of 15 bar (rectangular piston measuring 80 x 200 mm). After that, the entirety is removed from the mould and 10 test specimens of cords thus coated are cut out, for characterizing, in the shape of parallelepipeds measuring 7x7x60 mm.

[0256] The compound used as a coating elastomer compound is a diene elastomer compound conventionally used in tyres, based on natural (peptized) rubber and carbon black N330 (65 phr), also containing the following usual additives: sulfur (7 phr), sulfenamide accelerator (1 phr), ZnO (8 phr), stearic acid (0.7 phr), antioxidant (1.5 phr), cobalt naphthenate (1.5 phr) (phr meaning parts by weight per hundred parts of elastomer); the E10 modulus of the coating elastomer compound is around 10 MPa.

[0257] The test is carried out on a 6 cm length of cord, which is therefore coated with its surrounding elastomer compound (or coating elastomer compound) in the cured state, in the following way: air is injected into the inlet end of the cord at a pressure of 1 bar and the volume of air at the outlet end is measured using a flow meter (calibrated for example from 0 to 500 cm³/min). During the measurement, the sample of cord is immobilized in a compressed airtight seal (for example, a seal made of dense foam or of rubber) so that only the amount of air passing along the cord from one end to the other, along its longitudinal axis, is taken into account by the measurement; the airtightness of the airtight seal itself is checked beforehand using a solid elastomer-compound test specimen, that is to say one devoid of cord.

[0258] The higher the longitudinal impermeability of the cord, the lower the mean air flow

rate measured (averaged over the ten test specimens). As the measurement is taken with a precision of $\pm 0.2 \text{ cm}^3/\text{min}$, measured values of less than or equal to $0.2 \text{ cm}^3/\text{min}$ are considered to be zero; they correspond to a cord that can be described as airtight (completely airtight) along its axis (i.e. in its longitudinal direction).

[0259] Indicator of the penetrability of the strands by an elastomer compound

[0260] The ability of a strand to be penetrated by an elastomer compound was determined in the following tests by simulating the size of the radial passage windows formed by two adjacent threads $F2'$ of the intermediate layer $C2'$ and by two adjacent threads $F3'$ of the external layer $C3'$. Such windows are illustrated in Figure 23 which depicts a schematic view of an external strand along its main axis P and in Figure 24 which depicts the radial passage window S defined hereinabove.

[0261] Such an indicator of the penetrability of the strand gives an image of the impermeability of the strand to air. Specifically, the larger the size of the windows, the higher the penetrability indicator, the more elastomer compound is liable to penetrate the strand and the more impermeable the strand is to air. The permeability could also be determined by the permeability test described hereinabove applied to the strand. Nevertheless, for the sake of the speed at which the strands can be evaluated, the inventors favoured simulation and calculation of the windows S over the permeability test.

[0262] Influence of the directions of winding

[0263] Table 6 below collates the results of the permeability test and of the penetrability indicator test for three control cords $T1$, $T2$ and $T3$.

[0264] The results of these tests are indicated in base 100. Thus, a result higher than 100 for any one of these tests means that the cord or the strand tested exhibits superior impermeability or penetrability to the control cord or strand, in this instance the cord $T1$ or the strands of the cord $T1$.

[0265] It may be noted that the cord $T3$ has an impermeability that is over twice that of the control cord $T1$, and that this is solely by virtue of the ratio $(p3'-p2')/p3'$ of the intermediate $C2'$ and external $C3'$ layers of the external strands TE . The fact that the ratio $(p3'-p2')/p3'$ does not belong in the intervals of the cords according to the invention is caused by the fact that $Q'=1$ for the cord $T3$, and this changes the interval enabling the penetrability of the external strands TE to be maximized. Nevertheless, by transposition, it may be deduced that one essential feature of the invention is that of having, in the instances in which $Q'=2, 3$ or 4 , a ratio $(p3'-p2')/p3'$ conforming to the cords according to the invention enabling the penetrability of the external strands TE to

be maximized.

[0266] In spite of the fact that $Q=1$ for the cords T1, T2 and T3, by transposition, it may be deduced that one essential feature of the invention is that of having, in the instances in which $Q=2, 3$ or 4 , the external layers C3 and C3' wound in the same direction which is the opposite to the direction of winding of the L external strands TE (cord T1), which is a feature making it possible to ensure good impermeability of the cord.

Cord		C1	C2	C3
TI	Q/M/N	1/6/11	1/6/11	1/6/11
	d1/d2/d3	0.38/0.35/0.35	0.38/0.35/0.35	0.38/0.35/0.35
	direction for C1/pitch p1 (mm)	-/Inf	-/Inf	-/Inf
	direction for C2/pitch p2 (mm)	Z/14	S/14	Z/14
	direction for C3/pitch p3 (mm)	Z/20	S/20	Z/20
TE	Q'/M'/N'	1/6/11	1/6/11	1/6/11
	d1'/d2'/d3'	0.38/0.30/0.30	0.38/0.30/0.30	0.38/0.30/0.30
	direction for C1'/pitch p1' (mm)	inf	inf	inf
	direction for C2'/pitch p2' (mm)	Z/14	Z/14	Z/10
	direction for C3'/pitch p3' (mm)	Z/20	Z/20	Z/20
	(p3'-p2')/p3'	0.30	0.30	0.50
Direction of winding of the cord		S	S	S
Penetrability indicator for the external strand (base 100, T1)		100	100	360
Impermeability (base 100 T1)		100	<10	210

Table 6

[0267] Evaluation of the penetrability indicator for the external strands according to the pitch p_3' of the cord 50

[0268] Various external strands analogous to the external strand of the cords 50, 51 and 52 according to the invention were simulated by varying the value of p_2' for various values of p_3' , with all the other structural features of the cord remaining unchanged in comparison with the above description.

[0269] The results of these simulations are collated in the various Tables 50.1 to 52.6 in base 100 with respect, in each instance, to a control strand such that $(p_3' - p_2')/p_3' = 0.31$ for $Q' = 2$, $(p_3' - p_2')/p_3' = 0.33$ for $Q' = 3$ and $(p_3' - p_2')/p_3' = 0.25$ for $Q' = 4$. Thus, for a window size value St for the tested strand and for a window size value S_0 for the control strand, the penetrability indicator is equal to $St \cdot 100 / S_0$. Thus, a result higher than 100 means that the strand tested exhibits superior penetrability to the corresponding control strand. It is estimated that the size of the windows is significantly higher when the penetrability indicator is greater than or equal to 120, which means to say when the size of the windows in the strand tested is 20% higher than that of the control strand.

[0270] Each Table 50.1 to 52.6 respectively corresponds to a pitch p_3' equal to 12, 14, 16, 18, 20 and 23 mm.

[0271] It will be noted that, although the inter-thread distance l_2' increases when p_2' increases, the maximum value for the radial passage windows is obtained for l_2' values which are not necessarily the highest values. Thus, before carrying out the invention, a person skilled in the art, starting from the assumption that the lower l_2' , the lower the penetrability of the strand, would have difficulty in predicting a maximum penetrability for p_2' values that yield relatively low values for l_2' .

[0272] Within the interval for the ratio $(p_3' - p_2')/p_3'$ that ranges from 0.33 to 0.45 in instances in which $Q' = 2$, that ranges from 0.35 to 0.42 in instances in which $Q' = 3$, that ranges from 0.28 to 0.43 in instances in which $Q' = 4$, and for each p_3' value tested, the value for the penetrability indicator is significantly higher than that obtained for the corresponding control strand.

	External strands of the cord 50 which were tested with $p_3'=12$ mm								
direction for C1'/pitch p_1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p_2' (mm)	Z/6	Z/6.65	Z/7	Z/7.5	Z/8	Z/8.25	Z/8.5	Z/9	Z/9.5
direction for C3'/pitch p_3' (mm)	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12
$(p_3'-p_2')/p_3'$	0.50	0.45	0.42	0.38	0.33	0.31	0.29	0.25	0.21
l_2' (μm)	0	66	67	69	70	70	71	72	73
Penetrability indicator for the external strand	0	143	423	309	126	100	84	65	54

Table 50.1

	External strands of the cord 50 which were tested with $p_3'=14$ mm								
direction for C1'/pitch p_1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p_2' (mm)	Z/7.0	Z/7.65	Z/8.0	Z/8.5	Z/9.0	Z/9.5	Z/9.7	Z/10.0	Z/10.5
direction for C3'/pitch p_3' (mm)	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14
$(p_3'-p_2')/p_3'$	0.50	0.45	0.43	0.39	0.36	0.32	0.31	0.29	0.25
l_2' (μm)	67	69	70	71	72	73	73	73	74
Penetrability indicator for the external strand	61	129	256	1107	198	115	100	84	68

Table 50.2

	External strands of the cord 50 which were tested with p3'=16 mm											
direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p2' (mm)	Z/8.0	Z/8.5	Z/8.75	Z/9.0	Z/9.5	Z/10.0	Z/10.5	Z/11.0	Z/11.5	Z/12.0	Z/12.5	
direction for C3'/pitch p3' (mm)	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16
(p3'-p2')/p3'	0.50	0.47	0.45	0.44	0.41	0.38	0.34	0.31	0.28	0.25	0.22	
l2' (μm)	70	71	72	72	73	73	74	75	75	75	75	76
Penetrability indicator for the external strand	60	94	126	184	1180	313	147	100	78	64	56	

Table 50.3

	External strands of the cord 50 which were tested with p3'=18 mm														
direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p2' (mm)	Z/8.0	Z/8.5	Z/9.0	Z/9.5	Z/9.85	Z/10.0	Z/10.5	Z/11.0	Z/11.5	Z/12.0	Z/12.5	Z/13.0	Z/13.5	Z/14.0	
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.56	0.53	0.50	0.47	0.45	0.44	0.42	0.39	0.36	0.33	0.31	0.28	0.25	0.22	
l2' (μm)	70	71	72	73	73	73	74	75	75	75	76	76	76	77	
Penetrability indicator for the external strand	36	47	65	95	136	165	465	736	221	135	100	81	69	60	

Table 50.4

	External strands of the cord 50 which were tested with p3'=20 mm													
direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p2' (mm)	Z/8.0	Z/8.5	Z/9.0	Z/9.5	Z/10.0	Z/10.5	Z/11.0	Z/11.5	Z/12.0	Z/12.5	Z/13.0	Z/13.5	Z/13.75	Z/14.0
direction for C3'/pitch p3' (mm)	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20
(p3'-p2')/p3'	0.60	0.58	0.55	0.53	0.50	0.48	0.45	0.43	0.40	0.38	0.35	0.33	0.31	0.30
l2' (μm)	70	71	72	73	73	74	75	75	75	76	76	76	77	77
Penetrability indicator for the external strand	23	29	36	46	61	86	136	287	>5000	315	165	114	100	89

Table 50.5

	External strands of the cord 50 which were tested with p3'=23 mm									
direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p2' (mm)	Z/11.0	Z/11.5	Z/12.0	Z/12.5	Z/12.75	Z/13.0	Z/13.5	Z/14.0	Z/15.25	Z/15.8
direction for C3'/pitch p3' (mm)	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23
(p3'-p2')/p3'	0.52	0.50	0.48	0.46	0.45	0.43	0.41	0.39	0.34	0.31
l2' (μm)	75	75	75	76	76	76	76	77	77	77
Penetrability indicator for the external strand	48	61	82	119	151	202	562	878	133	100

Table 50.6

	External strands of the cord 51 which were tested with $p_3'=12$ mm								
direction for C1'/pitch p_1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p_2' (mm)	Z/6.5	Z/7.0	Z/7.5	Z/8.0	Z/8.25	Z/8.5	Z/9.0	Z/9.5	Z/10.0
direction for C3'/pitch p_3' (mm)	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12
$(p_3'-p_2')/p_3'$	0.46	0.42	0.38	0.33	0.31	0.29	0.25	0.21	0.17
l_2' (μm)	38	40	42	43	44	45	46	47	47
Penetrability indicator for the external strand	54	151	386	100	76	62	47	39	34

Table 51.1

	External strands of the cord 51 which were tested with $p_3'=14$ mm								
direction for C1'/pitch p_1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p_2' (mm)	Z/8.0	Z/8.15	Z/8.5	Z/9.0	Z/9.35	Z/9.5	Z/9.65	Z/10.0	Z/10.5
direction for C3'/pitch p_3' (mm)	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14
$(p_3'-p_2')/p_3'$	0.43	0.42	0.39	0.36	0.33	0.32	0.31	0.29	0.25
l_2' (μm)	43	44	45	46	46	47	47	47	48
Penetrability indicator for the external strand	109	152	948	172	100	86	75	60	47

Table 51.2

	External strands of the cord 51 which were tested with p3'=16 mm										
direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p2' (mm)	Z/8.0	Z/8.5	Z/9.0	Z/9.25	Z/9.5	Z/10.0	Z/10.5	Z/10.75	Z/11.0	Z/11.5	Z/12.0
direction for C3'/pitch p3' (mm)	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16
(p3'-p2')/p3'	0.50	0.47	0.44	0.42	0.41	0.38	0.34	0.33	0.31	0.28	0.25
l2' (μm)	43	45	46	46	47	47	48	48	49	49	50
Penetrability indicator for the external strand	35	54	95	143	274	427	132	100	82	61	50

Table 51.3

	External strands of the cord 51 which were tested with p3'=18 mm												
direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p2' (mm)	Z/8.0	Z/8.5	Z/9.0	Z/9.5	Z/10.0	Z/10.5	Z/11.0	Z/11.5	Z/12.0	Z/12.5	Z/13.0	Z/13.5	Z/14.0
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.56	0.53	0.50	0.47	0.44	0.42	0.39	0.36	0.33	0.31	0.28	0.25	0.22
l2' (μm)	43	45	46	47	47	48	49	49	50	50	50	51	51
Penetrability indicator for the external strand	27	25	33	48	76	159	4203	194	100	70	54	45	39

Table 51.4

	External strands of the cord 51 which were tested with p3'=20 mm													
direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p2' (mm)	Z/9.0	Z/9.5	Z/10.0	Z/10.5	Z/11.0	Z/11.5	Z/11.65	Z/12.0	Z/12.5	Z/13.0	Z/13.25	Z/13.5	Z/13.75	Z/14.0
direction for C3'/pitch p3' (mm)	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20
(p3'-p2')/p3'	0.55	0.53	0.50	0.48	0.45	0.43	0.42	0.40	0.38	0.35	0.34	0.33	0.31	0.30
l2' (μm)	46	47	47	48	49	49	49	50	50	50	51	51	51	51
Penetrability indicator for the external strand	23	30	39	53	79	139	177	445	450	159	115	100	85	75

Table 51.5

	External strands of the cord 51 which were tested with p3'=23 mm									
direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p2' (mm)	Z/12.5	Z/13.0	Z/13.25	Z/13.5	Z/14.0	Z/14.5	Z/15.0	Z/15.25	Z/15.5	Z/15.85
direction for C3'/pitch p3' (mm)	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23
(p3'-p2')/p3'	0.46	0.43	0.42	0.41	0.39	0.37	0.35	0.34	0.33	0.31
l2' (μm)	50	50	51	51	51	51	52	52	52	52
Penetrability indicator for the external strand	70	107	142	208	1535	315	149	119	100	82

Table 51.6

	External strands of the cord 52 which were tested with $p_3'=12$ mm													
direction for C1'/pitch p_1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p_2' (mm)	Z/6.5	Z/6.85	Z/7.0	Z/7.5	Z/7.75	Z/8.0	Z/8.5	Z/8.65	Z/8.75	Z/8.85	Z/9.0	9.5	10	
direction for C3'/pitch p_3' (mm)	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12	Z/12
$(p_3'-p_2')/p_3'$	0.46	0.43	0.42	0.38	0.35	0.33	0.29	0.28	0.27	0.26	0.25	0.21	0.17	
l_2' (μm)	24	26	27	29	30	31	33	33	34	34	34	35	36	
Penetrability indicator for the external strand	68	124	152	1308	634	275	140	124	116	109	100	81	69	

Table 52.1

	External strands of the cord 52 which were tested with $p_3'=14$ mm													
direction for C1'/pitch p_1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p_2' (mm)	Z/7.5	Z/8.0	Z/8.15	Z/8.35	Z/8.5	Z/9.0	Z/9.5	Z/10.0	Z/10.15	Z/10.25	Z/10.35	10.5	11.0	
direction for C3'/pitch p_3' (mm)	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14	Z/14
$(p_3'-p_2')/p_3'$	0.46	0.43	0.42	0.40	0.39	0.36	0.32	0.29	0.28	0.27	0.26	0.25	0.21	
l_2' (μm)	29	31	32	32	33	34	35	36	36	37	37	37	38	
Penetrability indicator for the external strand	70	127	160	235	349	825	217	133	121	114	108	100	82	

Table 52.2

	External strands of the cord 52 which were tested with p3'=16 mm												
direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p2' (mm)	Z/9.0	Z/9.15	Z/9.5	Z/10.0	Z/10.5	Z/11.0	Z/11.5	Z/11.65	Z/11.85	Z/12.0	Z/12.5	Z/13.0	Z/13.5
direction for C3'/pitch p3' (mm)	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16	Z/16
(p3'-p2')/p3'	0.44	0.43	0.42	0.41	0.38	0.34	0.31	0.28	0.27	0.26	0.25	0.22	0.19
l2' (μm)	34	35	35	35	36	37	38	38	39	39	39	39	39
Penetrability indicator for the external strand	113	134	153	225	1412	399	188	128	118	107	100	83	73

Table 52.3

	External strands of the cord 52 which were tested with p3'=18 mm												
direction for C1'/pitch p1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p2' (mm)	Z/9.5	Z/10.0	Z/10.25	Z/11.0	Z/11.35	Z/11.65	Z/12.0	Z/12.5	Z/13.0	Z/13.15	Z/13.35	Z/13.5	Z/14.0
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.47	0.44	0.43	0.39	0.37	0.35	0.33	0.31	0.28	0.27	0.26	0.25	0.22
l2' (μm)	35	36	37	38	38	39	39	39	40	40	40	40	41
Penetrability indicator for the external strand	70	104	132	444	>5000	623	290	171	125	116	106	100	85

Table 52.4

	External strands of the cord 52 which were tested with $p_3'=20$ mm													
direction for C1'/pitch p_1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p_2' (mm)	Z/9.5	Z/10.0	Z/10.5	Z/11.0	Z/11.5	Z/12.0	Z/12.5	Z/13.0	Z/13.5	Z/14.0	Z/14.5	Z/14.65	Z/14.85	Z/15.0
direction for C3'/pitch p_3' (mm)	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20	Z/20
$(p_3'-p_2')/p_3'$	0.53	0.50	0.48	0.45	0.43	0.40	0.38	0.35	0.33	0.30	0.28	0.27	0.26	0.25
l_2' (μ m)	35	36	37	38	38	39	39	40	40	41	41	41	41	41
Penetrability indicator for the external strand	41	53	70	98	150	284	1453	537	240	159	122	114	105	100

Table 52.5

	External strands of the cord 52 which were tested with $p_3'=23$ mm									
direction for C1'/pitch p_1' (mm)	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6	Z/6
direction for C2'/pitch p_2' (mm)	Z/11.0	Z/11.5	Z/12.0	Z/12.5	Z/13.0	Z/13.5	Z/14.0	Z/16.0	Z/17.0	Z/17.25
direction for C3'/pitch p_3' (mm)	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23	Z/23
$(p_3'-p_2')/p_3'$	0.52	0.50	0.48	0.46	0.43	0.41	0.39	0.30	0.26	0.25
l_2' (μ m)	38	38	39	39	40	40	41	42	42	42
Penetrability indicator for the external strand	44	55	69	91	127	199	406	169	108	100

Table 52.6

[0273] Evaluation of the penetrability indicator for the external strands of the cords 53 to 69

[0274] In a way similar to the cords 50, 51 and 52, various external strands of the cords 56 to 59 according to the various embodiments of the invention were simulated (the external strands of the cords 53, 54 and 55 are identical to those of the cords 50, 51 and 52) by varying the value of p_2' while fixing the value of p_3' to the value described hereinabove, with all the other structural features of each cord remaining unchanged in comparison with the above description.

[0275] The results of these simulations are collated in the various Tables 56 to 66 in base 100 with respect, in each instance, to a control strand such that $(p_3' - p_2')/p_3' = 0.31$ for $Q' = 2$, $(p_3' - p_2')/p_3' = 0.33$ for $Q' = 3$ and $(p_3' - p_2')/p_3' = 0.25$ for $Q' = 4$. Thus, for a window size value S_t for the tested strand and for a window size value S_0 for the control strand, the penetrability indicator is equal to $S_t \cdot 100 / S_0$. Thus, a result higher than 100 means that the strand tested exhibits superior penetrability to the corresponding control strand. It is estimated that the size of the windows is significantly higher when the penetrability indicator is greater than or equal to 120, which means to say when the size of the windows in the tested strand is 20% higher than that of the control strand.

[0276] It will be noted that, although the inter-thread distance l_2' increases when p_2' increases, the maximum value for the size of the radial passage windows is obtained for l_2' values which are not necessarily the highest values. Thus, before carrying out the invention, a person skilled in the art, starting from the assumption that the lower l_2' , the lower the penetrability of the strand, would have difficulty in predicting a maximum penetrability for p_2' values that yield relatively low values for l_2' .

[0277] Within the interval for the ratio $(p_3' - p_2')/p_3'$ that ranges from 0.33 to 0.45 in instances in which $Q' = 2$, that ranges from 0.35 to 0.42 in instances in which $Q' = 3$, and that ranges from 0.28 to 0.43 in instances in which $Q' = 4$, and for each p_3' value tested, the value for the penetrability indicator is significantly higher than that obtained for the corresponding control strand.

	External strands of the cord 56												
direction for C1'/pitch p1' (mm)	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0
direction for C2'/pitch p2' (mm)	Z/9.75	Z/10	Z/10.25	Z/10.5	Z/10.75	Z/11	Z/11.25	Z/11.5	Z/11.75	Z/12	Z/12.25	Z/12.5	Z/12.75
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.46	0.44	0.43	0.42	0.40	0.39	0.38	0.36	0.35	0.33	0.32	0.31	0.29
l2' (µm)	99	99	100	100	101	101	102	102	102	103	103	103	103
Penetrability indicator for the external strand	91	125	163	254	536	>5000	510	268	185	143	117	100	88

Table 56

	External strands of the cord 57												
direction for C1'/pitch p1' (mm)	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0
direction for C2'/pitch p2' (mm)	Z/9.75	Z/10	Z/10.25	Z/10.5	Z/10.75	Z/11	Z/11.25	Z/11.5	Z/11.75	Z/12	Z/12.25	Z/12.5	Z/12.75
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.46	0.44	0.43	0.42	0.40	0.39	0.38	0.36	0.35	0.33	0.32	0.31	0.29
l2' (µm)	67	68	69	69	70	70	71	71	71	72	72	72	73
Penetrability indicator for the external strand	41	69	106	123	148	331	1954	260	143	100	78	64	55

Table 57

	External strands of the cord 58												
direction for C1'/pitch p1' (mm)	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0
direction for C2'/pitch p2' (mm)	Z/10	Z/10.25	Z/10.5	Z/10.75	Z/11.25	Z/11.5	Z/11.75	Z/12.25	Z/12.75	Z/13	Z/13.25	Z/13.5	Z/13.75
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.44	0.43	0.42	0.40	0.38	0.36	0.35	0.32	0.29	0.28	0.26	0.25	0.24
l2' (μm)	55	55	56	57	58	58	59	60	60	61	61	61	62
Penetrability indicator for the external strand	95	123	128	174	477	2306	883	250	152	129	112	100	91

Table 58

	External strands of the cord 59												
direction for C1'/pitch p1' (mm)	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0
direction for C2'/pitch p2' (mm)	Z/9.75	Z/10	Z/10.25	Z/10.5	Z/10.75	Z/11	Z/11.25	Z/11.5	Z/11.75	Z/12	Z/12.25	Z/12.5	Z/12.75
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.46	0.44	0.43	0.42	0.40	0.39	0.38	0.36	0.35	0.33	0.32	0.31	0.29
l2' (μm)	111	112	112	113	113	114	114	115	115	116	116	116	117
Penetrability indicator for the external strand	93	126	140	209	389	2058	671	297	194	146	112	100	87

Table 59

	External strands of the cord 60												
direction for C1'/pitch p1' (mm)	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0
direction for C2'/pitch p2' (mm)	Z/9.75	Z/10	Z/10.25	Z/10.5	Z/10.75	Z/11	Z/11.25	Z/11.5	Z/11.75	Z/12	Z/12.25	Z/12.5	Z/12.75
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.46	0.44	0.43	0.42	0.40	0.39	0.38	0.36	0.35	0.33	0.32	0.31	0.29
l2' (μm)	77	78	78	79	80	80	81	81	82	82	83	83	84
Penetrability indicator for the external strand	37	43	83	131	170	221	1707	319	150	100	76	62	53

Table 60

	External strands of the cord 61												
direction for C1'/pitch p1' (mm)	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0
direction for C2'/pitch p2' (mm)	Z/10	Z/10.25	Z/10.75	Z/11.25	Z/11.5	Z/11.75	Z/12.25	Z/12.5	Z/12.75	Z/13	Z/13.25	Z/13.5	Z/13.75
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.44	0.43	0.40	0.38	0.36	0.35	0.32	0.31	0.29	0.28	0.26	0.25	0.24
l2' (μm)	63.2	64.1	65.7	67.1	67.7	68.3	69.4	69.9	70.4	70.8	71.2	71.6	72
Penetrability indicator for the external strand	87	125	151	364	1010	1502	270	196	156	130	113	100	90

Table 61

	External strands of the cords 62, 64, 67												
direction for C1'/pitch p1' (mm)	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0
direction for C2'/pitch p2' (mm)	Z/9.75	Z/10	Z/10.25	Z/10.5	Z/10.75	Z/11	Z/11.25	Z/11.5	Z/11.75	Z/12	Z/12.25	Z/12.5	Z/12.75
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.46	0.44	0.43	0.42	0.40	0.39	0.38	0.36	0.35	0.33	0.32	0.31	0.29
l2' (μm)	90	91	91	91	92	92	92	92	93	93	93	93	93
Penetrability indicator for the external strand	89	125	155	237	474	>5000	562	279	189	144	118	100	87

Table 62

	External strands of the cords 63, 65, 68												
direction for C1'/pitch p1' (mm)	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0
direction for C2'/pitch p2' (mm)	Z/9.75	Z/10	Z/10.25	Z/10.5	Z/10.75	Z/11	Z/11.25	Z/11.5	Z/11.75	Z/12	Z/12.25	Z/12.5	Z/12.75
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.46	0.44	0.43	0.42	0.40	0.39	0.38	0.36	0.35	0.33	0.32	0.31	0.29
l2' (μm)	63	64	64	64	65	65	65	66	66	66	66	67	67
Penetrability indicator for the external strand	41	49	64	124	172	287	>5000	278	145	100	77	63	54

Table 63

	External strands of the cord 66, 69												
direction for C1'/pitch p1' (mm)	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0	Z/6.0
direction for C2'/pitch p2' (mm)	Z/10	Z/10.25	Z/10.5	Z/10.75	Z/11.25	Z/11.5	Z/11.75	Z/12.25	Z/12.5	Z/13	Z/13.25	Z/13.5	Z/13.75
direction for C3'/pitch p3' (mm)	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18	Z/18
(p3'-p2')/p3'	0.44	0.43	0.42	0.40	0.38	0.36	0.35	0.32	0.31	0.28	0.26	0.25	0.24
l2' (µm)	52	53	53	54	54	55	55	56	56	56	57	57	57
Penetrability indicator for the external strand	89	124	139	171	448	1734	1009	257	191	129	113	100	90

Table 66

[0278] Tables 56 to 66 show that, for varying cord constructions, the penetration of the elastomer compound into the external strands, and therefore the ability this elastomer compound has to access the internal strand, is significantly improved for a ratio $(p_3' - p_2')/p_3'$ that ranges from 0.33 to 0.45 in instances in which $Q'=2$, that ranges from 0.35 to 0.42 in instances in which $Q'=3$, and that ranges from 0.28 to 0.43 in instances in which $Q'=4$, by comparison with the control cords for which $(p_3' - p_2')/p_3' = 0.31$ for $Q'=2$, $(p_3' - p_2')/p_3' = 0.33$, for $Q'=3$ and $(p_3' - p_2')/p_3' = 0.25$ in instances in which $Q'=4$.

[0279] Of course, the invention is not restricted to the exemplary embodiments described above.

[0280] For reasons of industrial feasibility, of cost and of overall performance, it is preferable to implement the invention with linear threads, that is to say straight threads, having a conventional circular cross section.

[0281] It will also be possible to combine the characteristics of the various embodiments described or envisaged above, with the proviso that these characteristics are compatible with one another.

[0282] In one embodiment not described hereinabove, in the case where $L=7$, $DI/DE \geq 1.30$, for preference $DI/DE \geq 1.35$ and more preferably $DI/DE \geq 1.40$ and $DI/DE \leq 1.70$, for preference $DI/DE \leq 1.65$ and more preferably, $DI/DE \leq 1.60$.

[0283] In another embodiment not described hereinabove, in the case where $L=8$, $DI/DE \geq 1.60$, for preference $DI/DE \geq 1.65$ and more preferably $DI/DE \geq 1.70$ and $DI/DE \leq 2.0$, for preference $DI/DE \leq 1.95$ and more preferably $DI/DE \leq 1.90$.

[0284] In yet another embodiment not described hereinabove, in the case where $L=9$, $DI/DE \geq 2.00$, for preference $DI/DE \geq 2.05$ and more preferably $DI/DE \geq 2.10$ and $DI/DE \leq 2.50$, for preference $DI/DE \leq 2.45$ and more preferably, $DI/DE \leq 2.40$.

[0285] In a first embodiment not described hereinabove, in the case where the internal strand TI has two layers, or three layers, the intermediate layer of each external strand is wound around the internal layer of each external strand in a direction of winding identical to the direction of winding of the cord.

[0286] In a first alternative of this first embodiment, in which $Q > 1$, the internal layer of the internal strand is wound in a helix with a direction of winding identical to the direction of winding of the cord. In a second alternative of this first embodiment, in which $Q > 1$, the internal layer of the internal strand is wound in a helix with a direction of winding opposite to the direction of winding of the cord.

[0287] In a second embodiment of the cord not described hereinabove, in the case where the internal strand TI has two layers, or three layers, the intermediate layer of each external strand is wound around the internal layer of each external strand in a direction of winding opposite to the direction of winding of the cord. In a first alternative

of this second embodiment, in which $Q > 1$, the internal layer of the internal strand is wound in a helix with a direction of winding identical to the direction of winding of the cord.

[0288] The directions of winding of the embodiments and alternatives envisaged hereinabove may just as well be S as Z.

[0289] It is to be understood that, if any prior art is referred to herein, such reference does not constitute an admission that the prior art forms a part of the common general knowledge in the art, in Australia or any other country.

[0290] In the claims which follow and in the preceding description, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

CLAIMS

1. Two-layer multi-strand cord, wherein the cord comprises:
 - an internal layer of the cord made up of an internal strand having at least two layers comprising:
 - an internal layer made up of Q internal thread(s) and
 - an external layer made up of N external threads wound around the internal layer,
 - an external layer of the cord made up of L>1 external strands having three layers comprising:
 - an internal layer made up of Q'=2, 3 or 4 internal threads wound with a pitch p1', the internal layer being wound in an internal-layer direction of each external strand,
 - an intermediate layer made up of M' intermediate threads, wound around the internal layer with a pitch p2', the intermediate layer being wound in an intermediate-layer direction of each external strand, and
 - an external layer made up of N' external threads wound around the intermediate layer with a pitch p3',

wherein:

- p1' is different from p2' and/or the internal-layer direction of each external strand is different from the intermediate-layer direction of each external strand;
- the external layer of the cord is wound around the internal layer of the cord in a direction of winding of the cord;
- each external layer of each internal and external strand is wound respectively around the internal and intermediate layer of each internal and external strand respectively in the same direction of winding that is the opposite of the direction of winding of the cord;
- the external layer of the cord is desaturated;
- the intermediate layer of each external strand is desaturated;
- the external layer of each external strand is desaturated; and
- the pitches p2' and p3' satisfy the relationship:
 - $0.36 \leq (p3'-p2')/p3' \leq 0.45$ in instances in which Q'=2,
 - $0.36 \leq (p3'-p2')/p3' \leq 0.42$ in instances in which Q'=3,
 - $0.36 \leq (p3'-p2')/p3' \leq 0.43$ in instances in which Q'=4,

wherein the inter-thread distance of the intermediate layer of the external strand is greater than or equal to 35 μm .

2. Cord according to the preceding claim, in which:

- $0.38 \leq (p_3' - p_2')/p_3'$ in instances in which $Q'=20.38 \leq (p_3' - p_2')/p_3'$ in instances in which $Q'=3$.

3. Cord according to any one of the preceding claims, in which:

- $(p_3' - p_2')/p_3' \leq 0.42$ and preferably $(p_3' - p_2')/p_3' \leq 0.40$ in instances in which $Q'=2$,

- $(p_3' - p_2')/p_3' \leq 0.40$ in instances in which $Q'=3$,

- $(p_3' - p_2')/p_3' \leq 0.40$ and preferably $(p_3' - p_2')/p_3' \leq 0.38$ in instances in which $Q'=4$.

4. Cord according to any one of the preceding claims, in which the pitch p_1' is such that $3 \text{ mm} \leq p_1' \leq 16 \text{ mm}$, for preference $4 \text{ mm} \leq p_1' \leq 13 \text{ mm}$, and more preferably $5 \text{ mm} \leq p_1' \leq 10 \text{ mm}$.

5. Cord according to any one of the preceding claims, in which the pitch p_2' is such that $8 \text{ mm} \leq p_2' \leq 20 \text{ mm}$, for preference $9 \text{ mm} \leq p_2' \leq 18 \text{ mm}$, and more preferably $10 \text{ mm} \leq p_2' \leq 16 \text{ mm}$.

6. Cord according to any one of the preceding claims, in which the pitch p_3' is such that $10 \text{ mm} \leq p_3' \leq 40 \text{ mm}$, for preference $12 \text{ mm} \leq p_3' \leq 30 \text{ mm}$, and more preferably $15 \text{ mm} \leq p_3' \leq 25 \text{ mm}$.

7. Cord according to any one of the preceding claims, in which the internal strand TI has a diameter DI and each external strand TE has a diameter DE which are such that:

- in instances in which $L=6$, $DI/DE > 1$, for preference $DI/DE \geq 1.05$ and more preferably $DI/DE \geq 1.10$,

- in instances in which $L=7$, $DI/DE \geq 1.30$, for preference $DI/DE \geq 1.35$ and more preferably $DI/DE \geq 1.40$,

- in instances in which $L=8$, $DI/DE \geq 1.60$, for preference $DI/DE \geq 1.65$ and more preferably $DI/DE \geq 1.70$,

- in instances in which $L=9$, $DI/DE \geq 2.00$, for preference $DI/DE \geq 2.05$ and more preferably $DI/DE \geq 2.10$.

8. Cord according to any one of the preceding claims, in which the internal strand TI has a diameter DI and each external strand TE has a diameter DE which are such that:

- in instances in which $L=6$, $DI/DE \leq 1.40$, for preference $DI/DE \leq 1.35$ and more preferably $DI/DE \leq 1.30$,

- in instances in which $L=7$, $DI/DE \leq 1.70$, for preference $DI/DE \leq 1.65$ and more preferably $DI/DE \leq 1.60$,

- in instances in which $L=8$, $DI/DE \leq 2.0$, for preference $DI/DE \leq 1.95$ and more

preferably $DI/DE \leq 1.90$,

- in instances in which $L=9$, $DI/DE \leq 2.50$, for preference $DI/DE \leq 2.45$ and more preferably $DI/DE \leq 2.40$.

9. Cord according to any one of the preceding claims, in which L is equal to 6, 7, 8, 9 or 10, for preference $L=6, 7$ or 8 and more preferably $L=6$.

10. Cord according to any one of the preceding claims, in which $M'=7, 8, 9$ or 10 and $N'=12, 13, 14$ or 15.

11. Cord according to any one of the preceding claims, in which the sum $SI2'$ of the inter-thread distances of the intermediate layer of each external strand is such that $SI2' < d3'$ where $d3'$ is the diameter of each external thread of each external strand, preferably $SI2' \leq 0.8 \times d3'$.

12. Cord according to any one of the preceding claims, in which the external layer of each external strand is completely unsaturated.

13. Cord according to any one of the preceding claims, in which the external layer of the internal strand is desaturated, preferably completely unsaturated.

14. Cord according to any one of the preceding claims, in which each internal thread of each external strand has a diameter $d1'$ greater than or equal to the diameter $d2'$ of each intermediate thread of each external strand, and preferably $1 \leq d1'/d2' \leq 1.10$.

15. Tyre comprising the cord according to any one of the preceding claims.

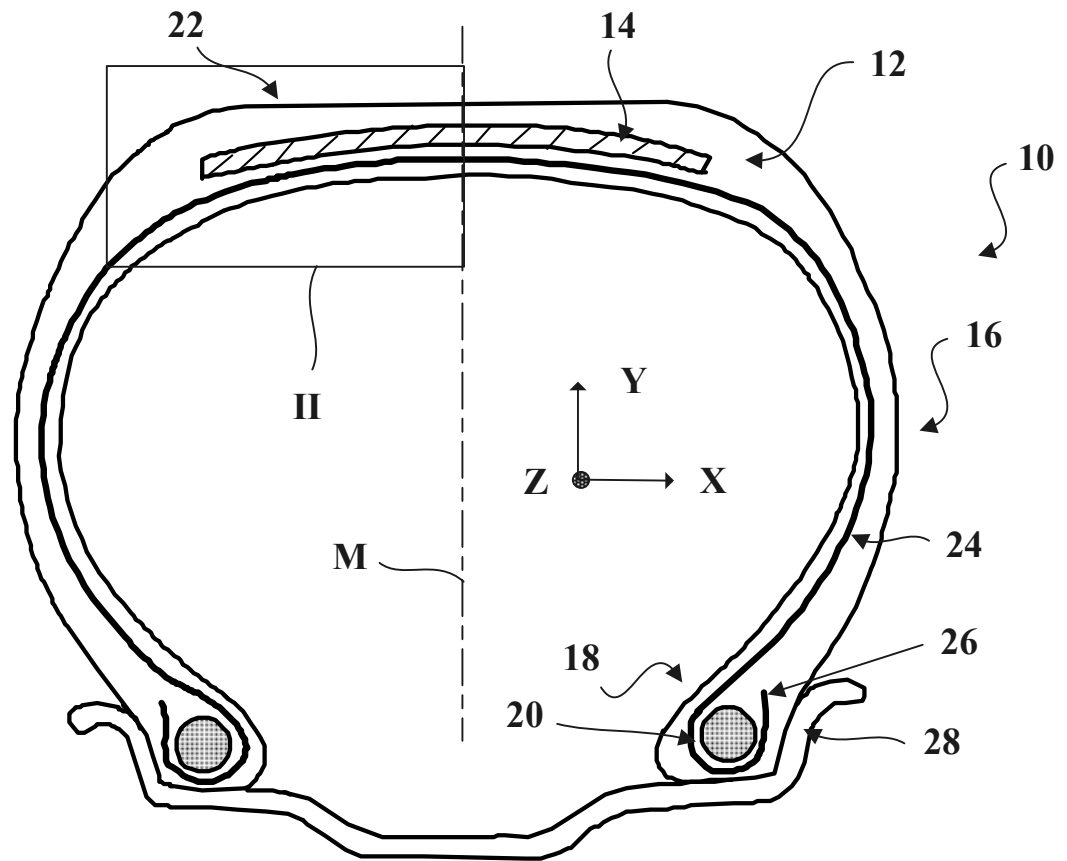


FIG. 1

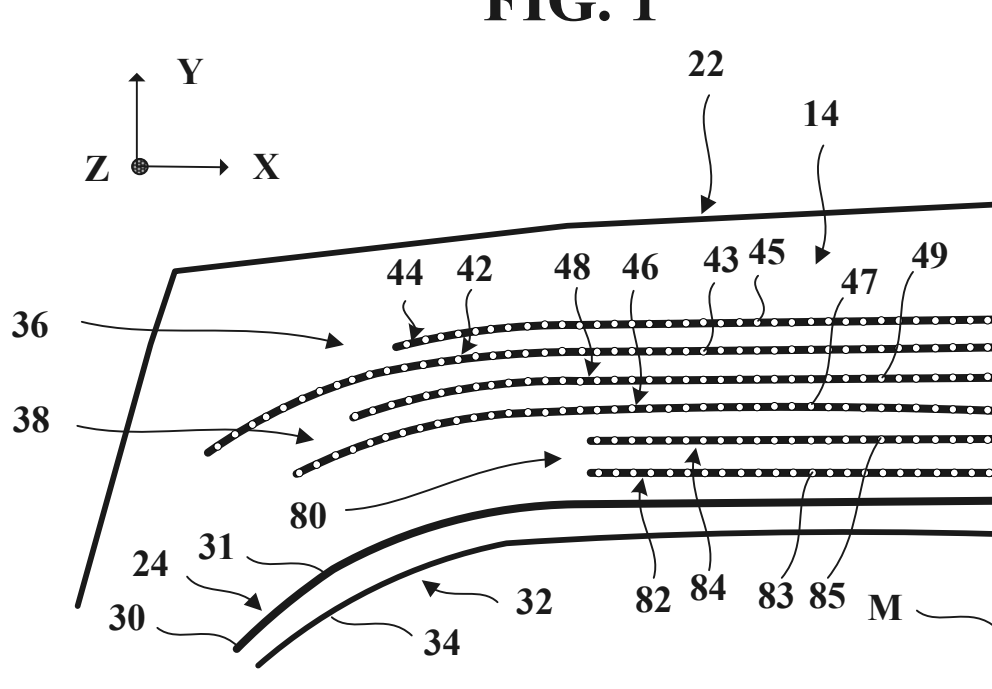


FIG. 2

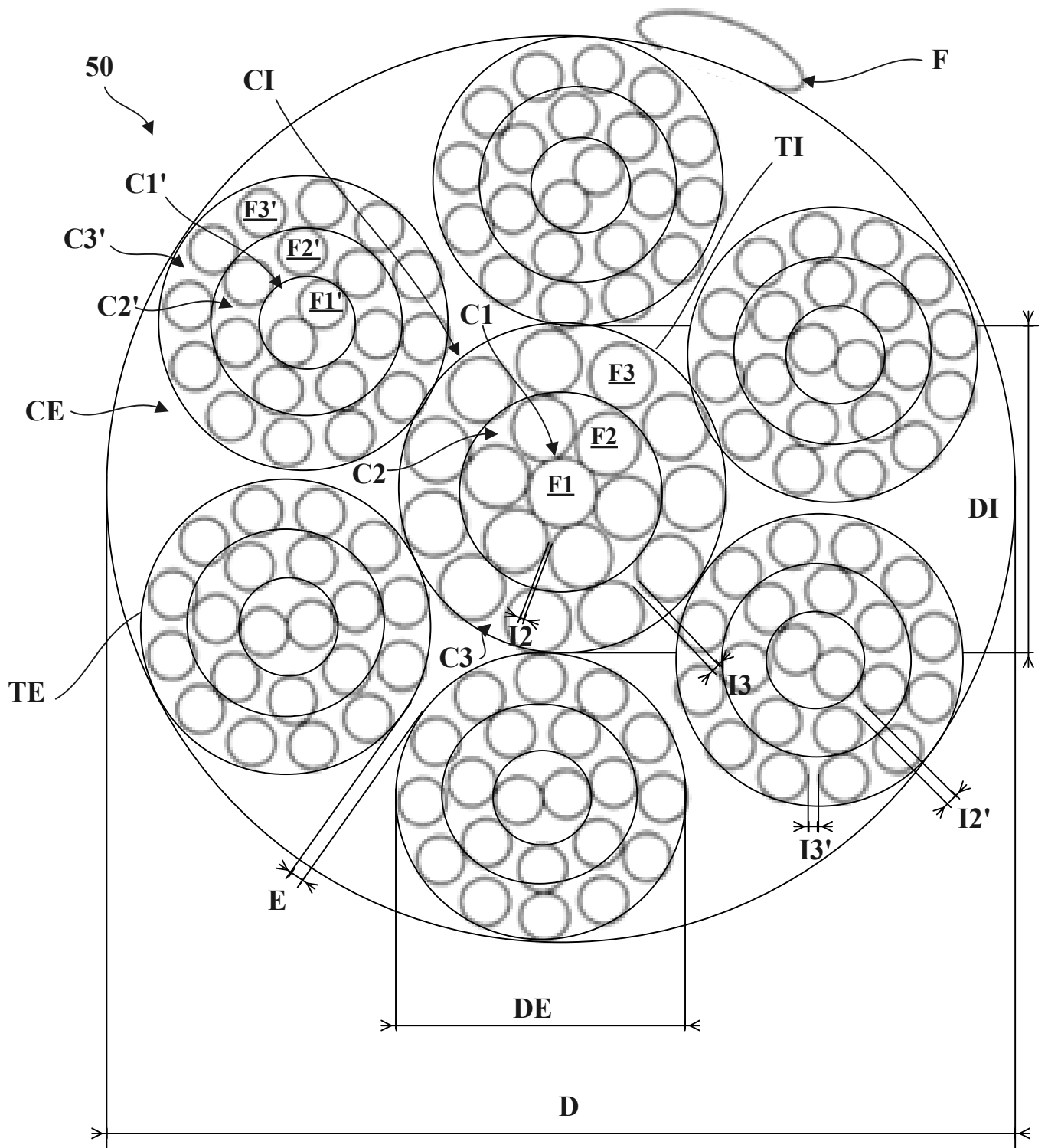


FIG. 3

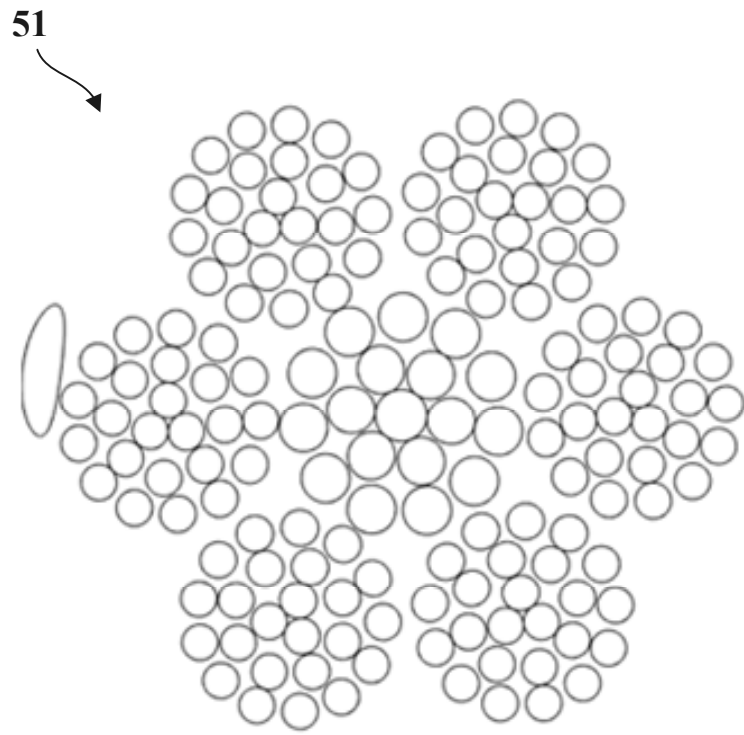


FIG. 4

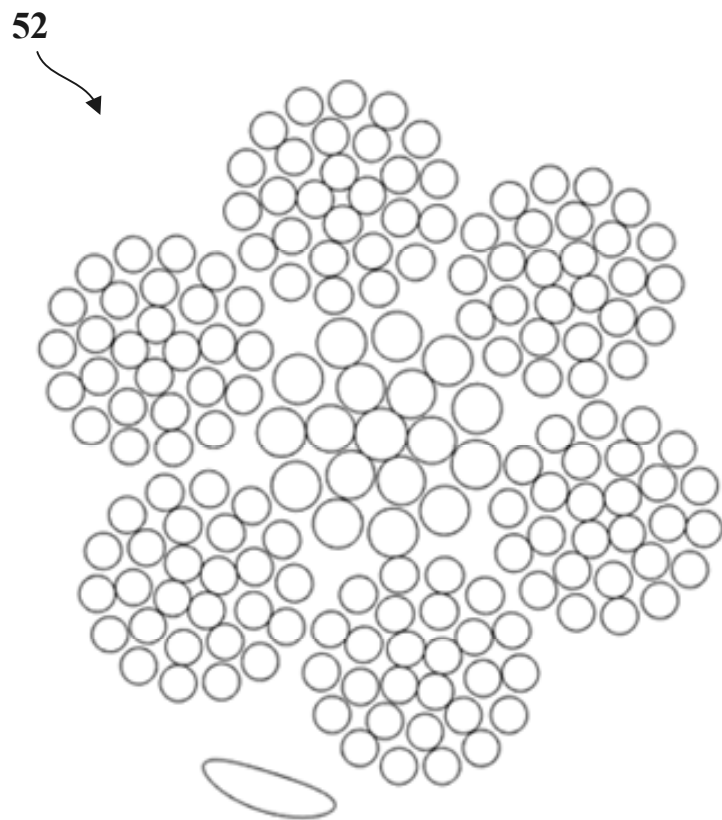


FIG. 5

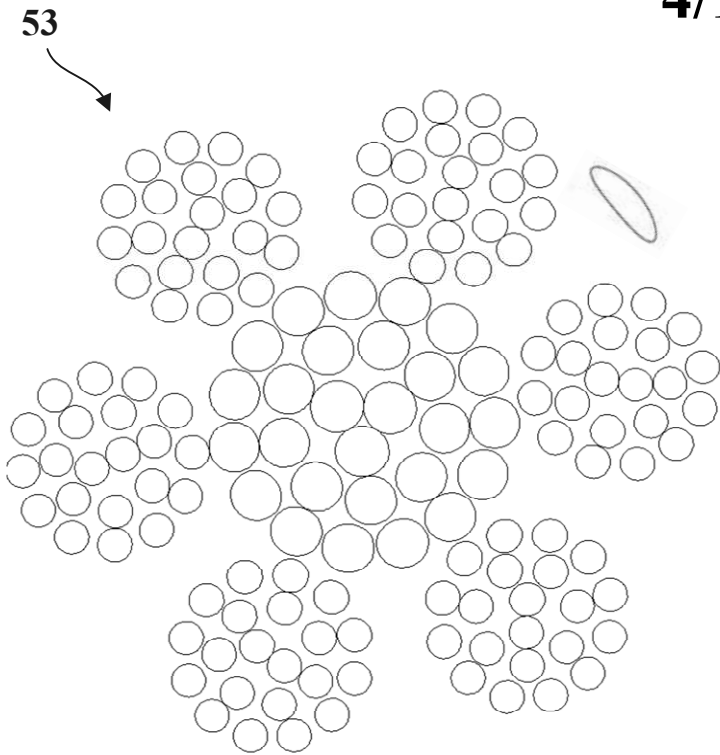


FIG. 6

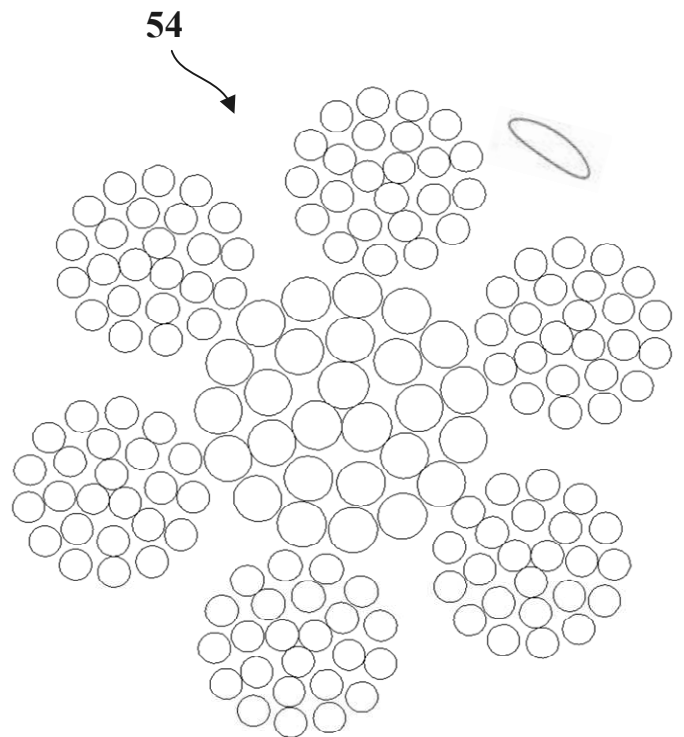


FIG. 7

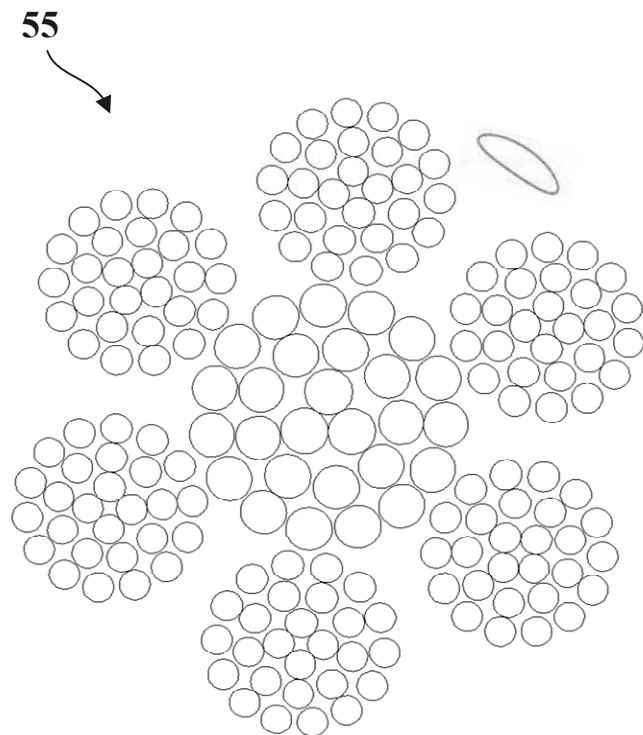


FIG. 8

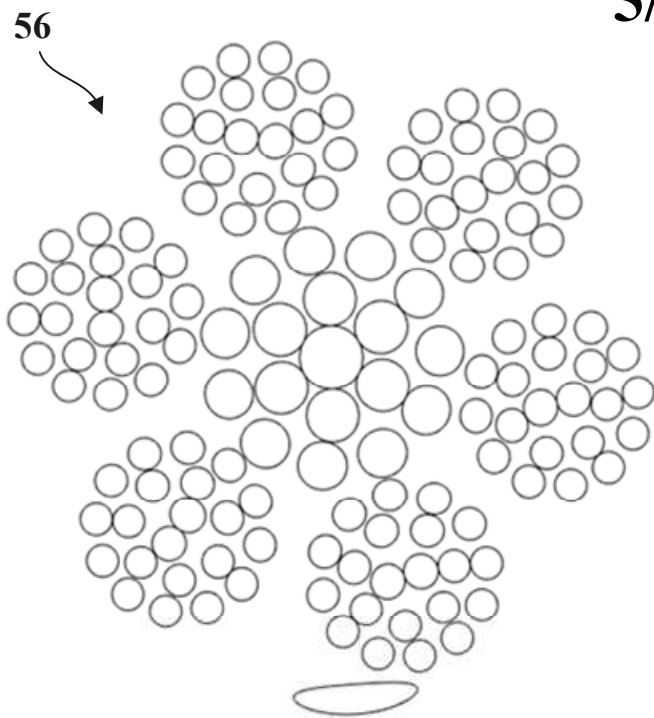


FIG. 9

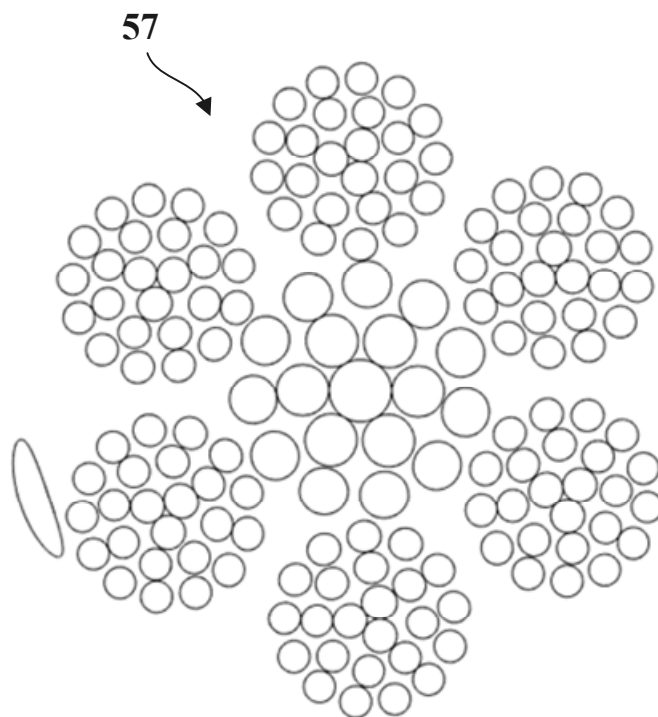


FIG. 10

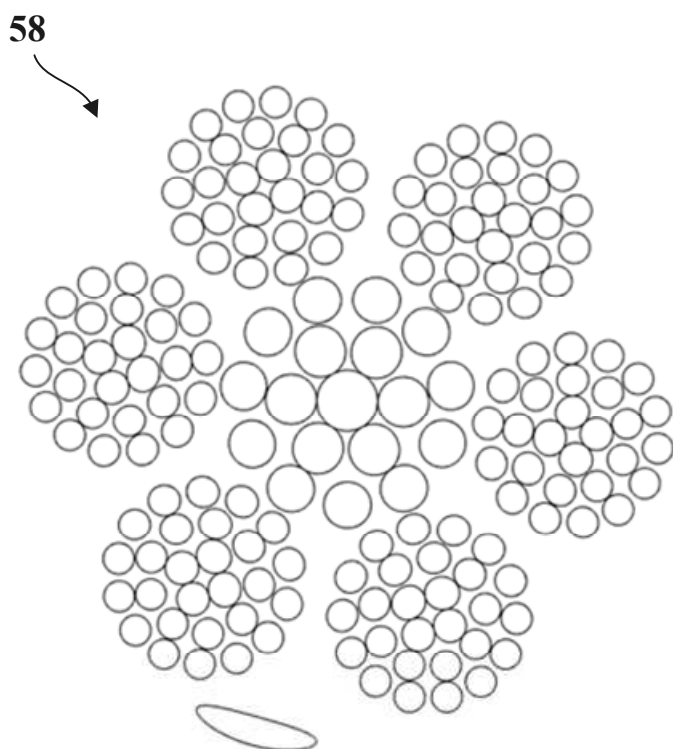


FIG. 11

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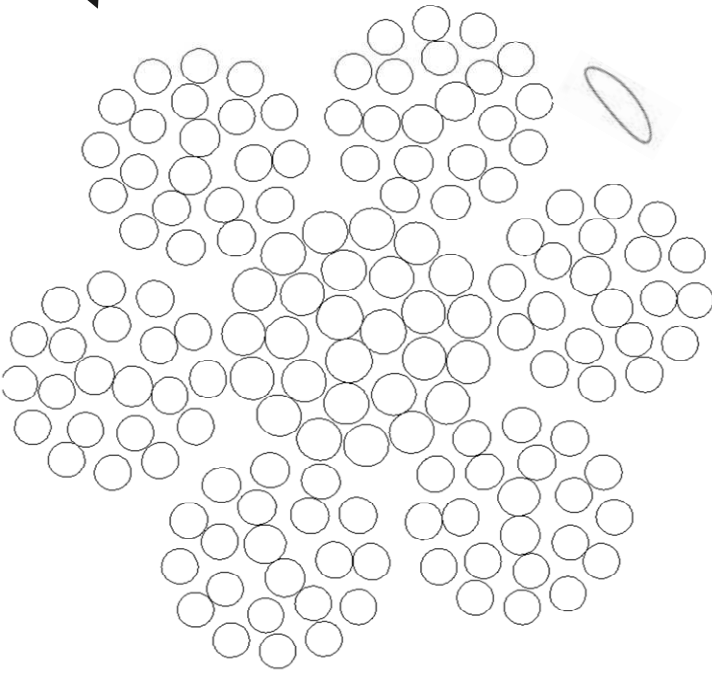


FIG. 12

60

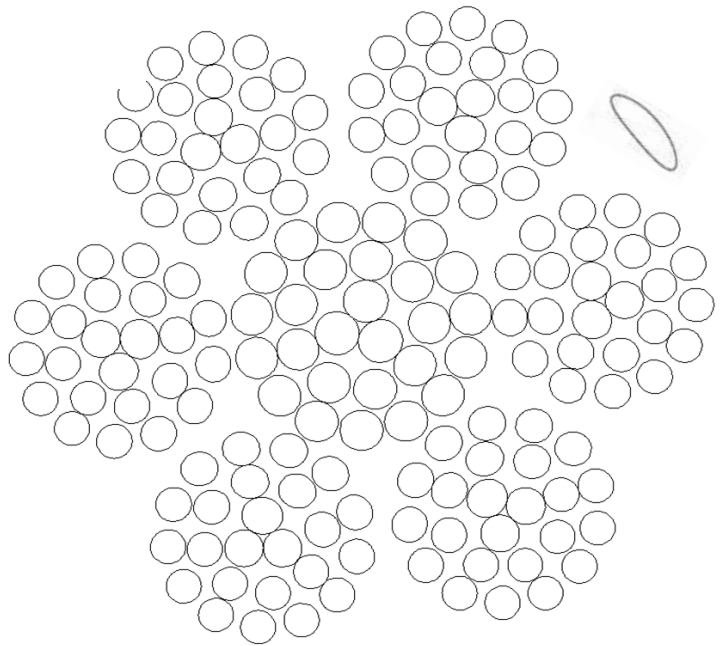


FIG. 14

61

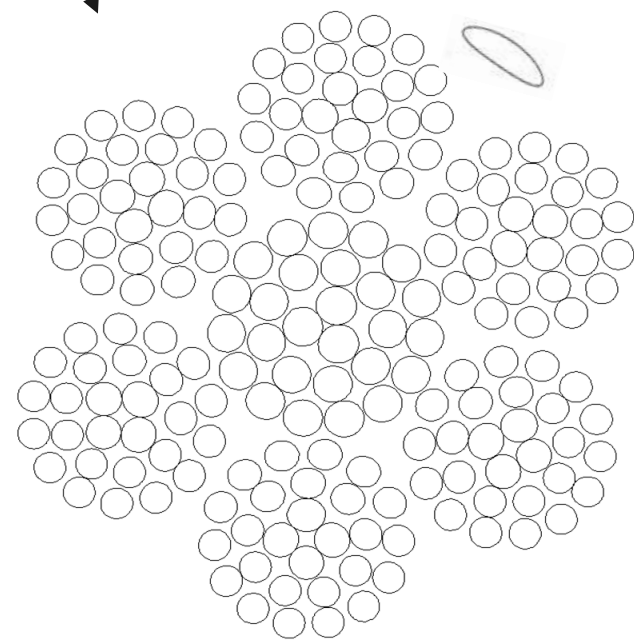


FIG. 13

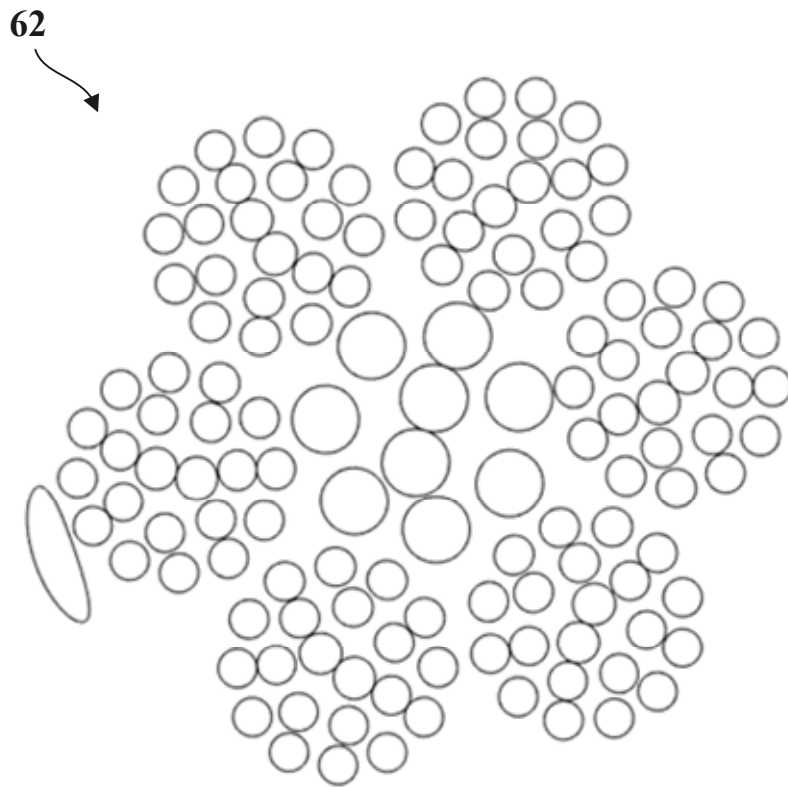


FIG. 15

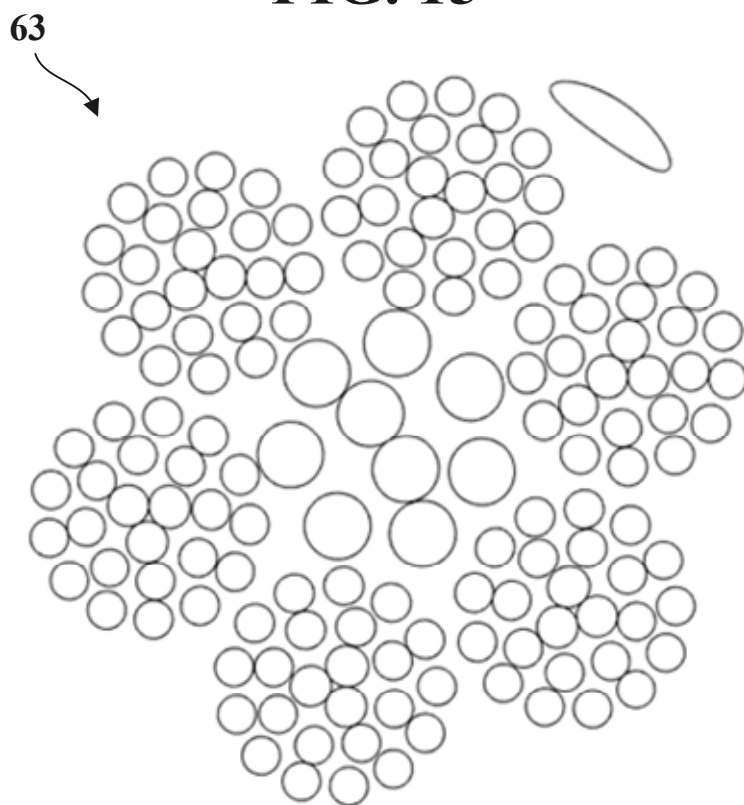


FIG. 16

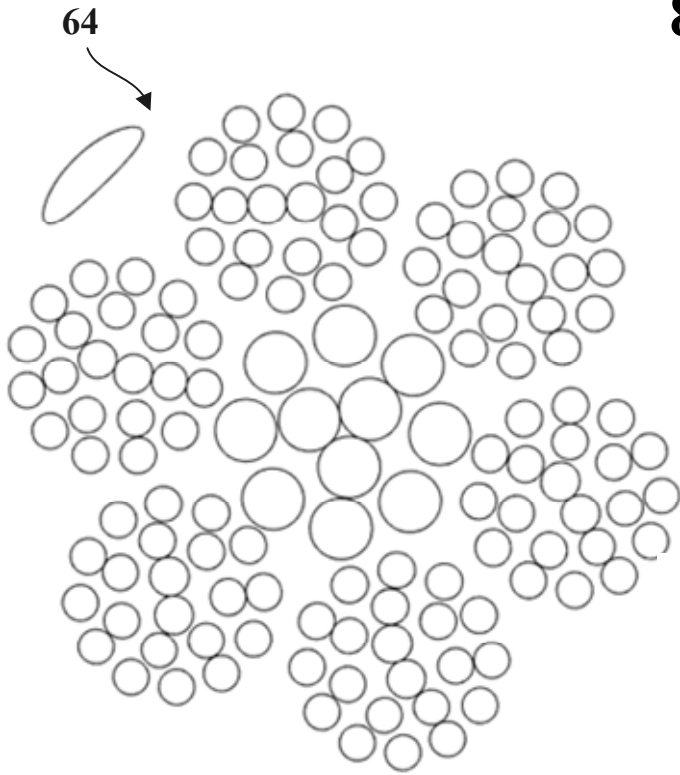


FIG. 17

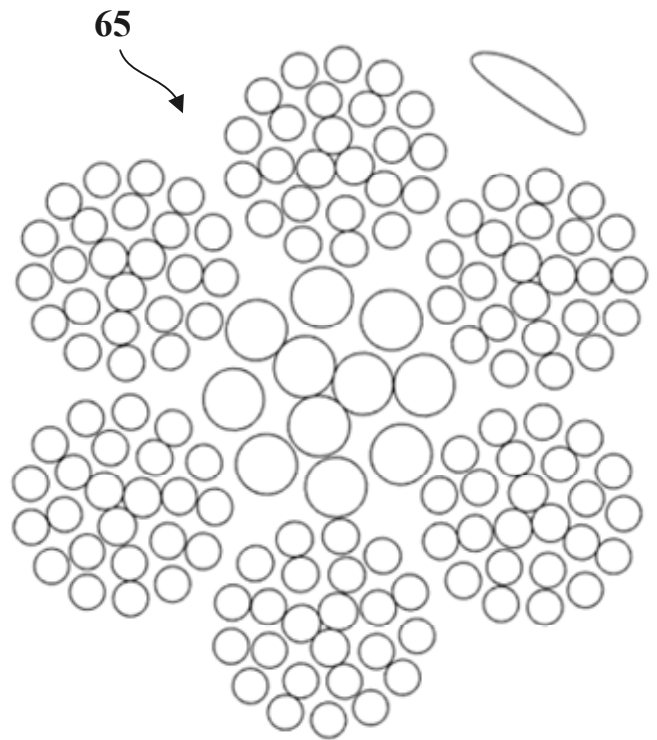


FIG. 18

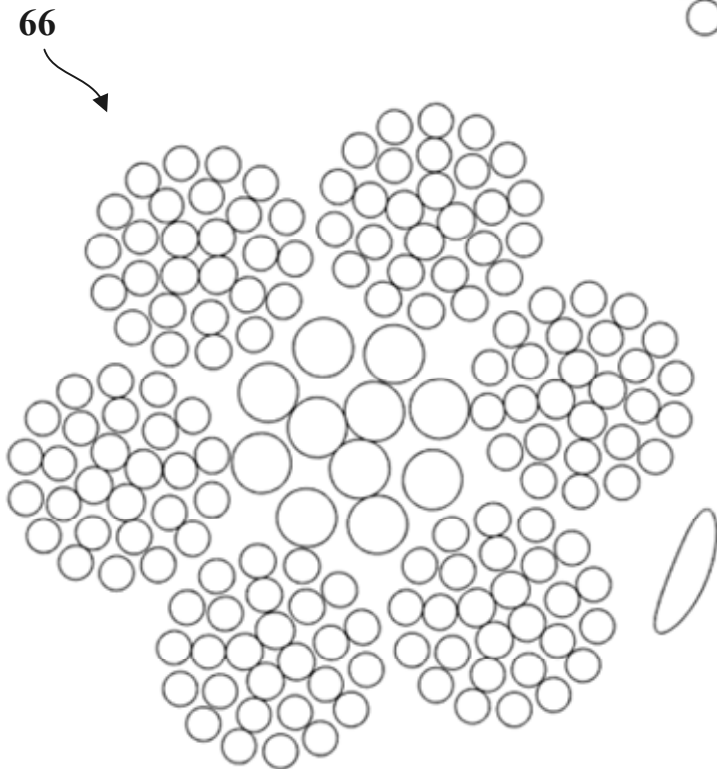


FIG. 19

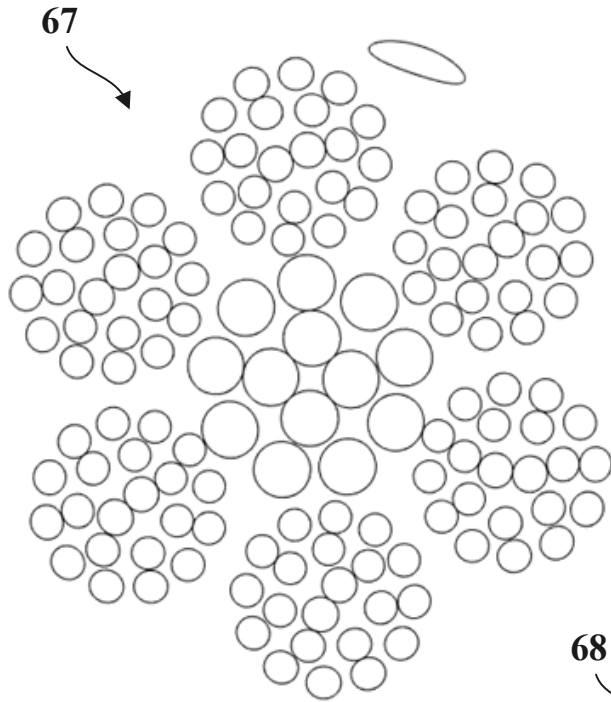


FIG. 20

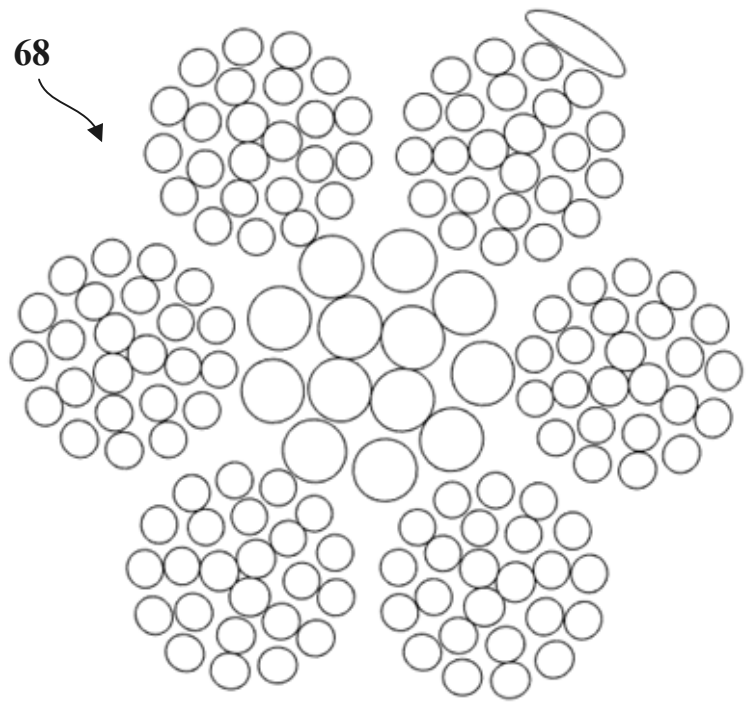


FIG. 21

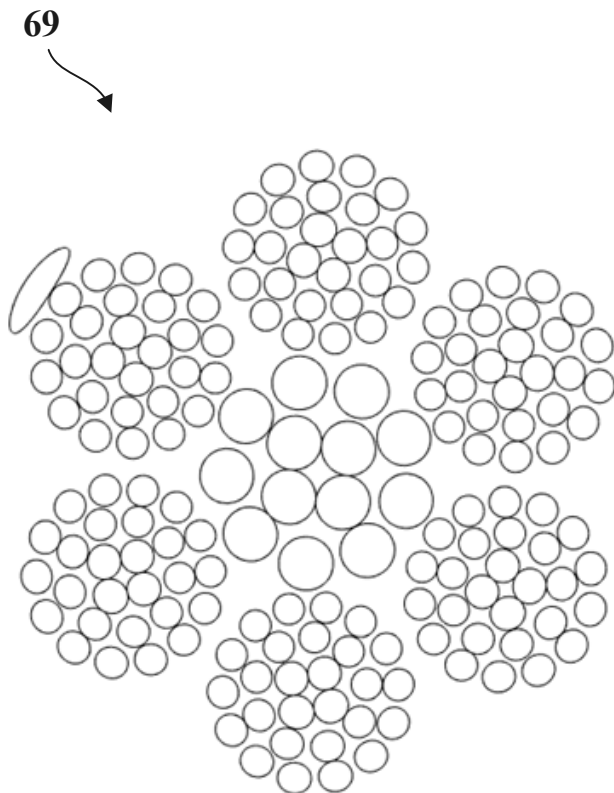


FIG. 22

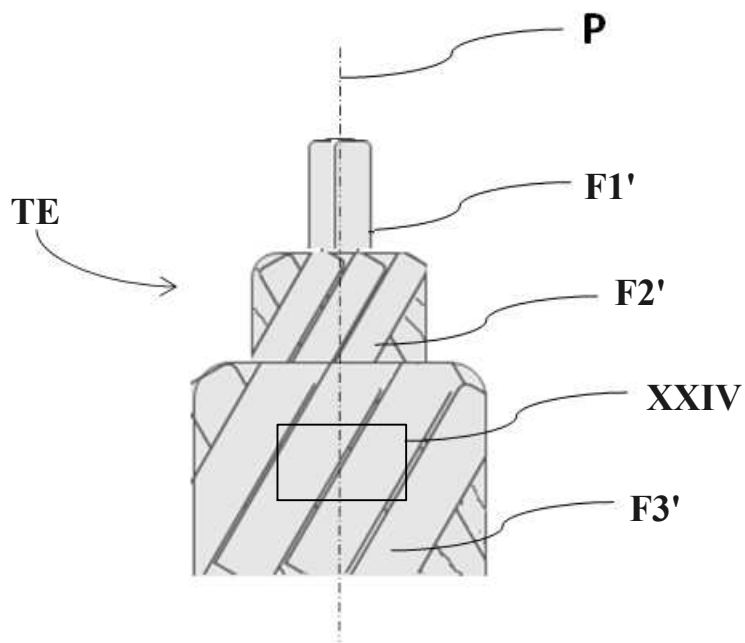


FIG. 23

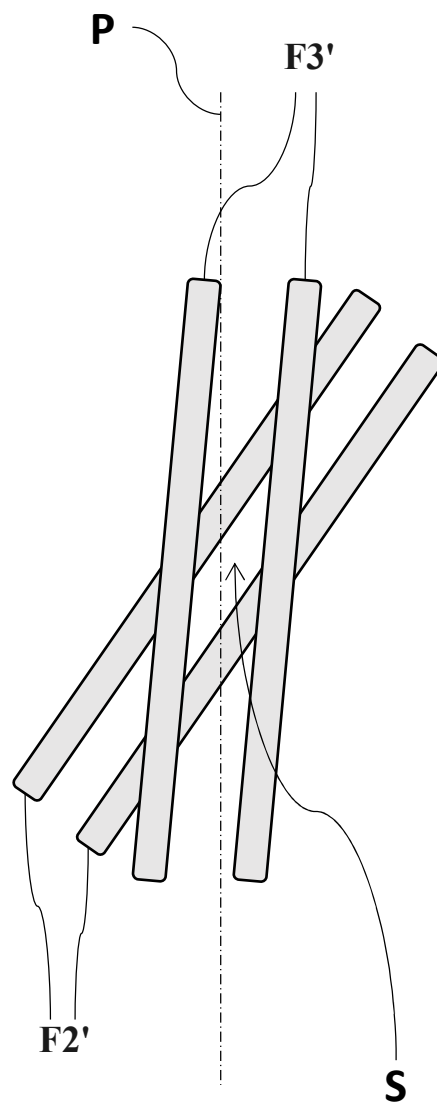


FIG. 24