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(54) **Title:** TWO-LAYER MULTI-STRAND CABLE HAVING A SHEATHED INNER LAYER AND IMPROVED PENETRABILITY

(54) **Titre :** CÂBLE MULTI-TORONS À DEUX COUCHES AVEC COUCHE INTERNE GAINÉE À PÉNÉTRABILITÉ AMÉLIORÉE

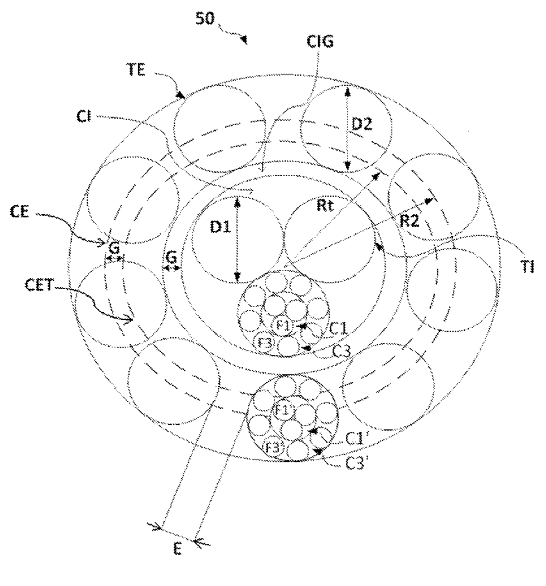

Fig.4

(57) **Abstract:** The invention relates to a two-layer multi-strand cable (50) comprising: - an inner layer (CI) that has two layers (C1, C3) and consists of K≥1 inner strand(s) (TI), and an outer layer (CE) consisting of L>1 outer strands (TE) that have two plies (C1', C3 ') and are wound around the inner layer (CI) at a helix radius R2. The outer plies (C3, C3') of each inner and outer strand (TI, TE) are desaturated. The cable (50) is obtained by a method involving a step of manufacturing the sheathed inner layer (CIG) in which the inner layer (CI) is surrounded by an elastomer composition having a thickness G and then by an outer layer (CE), G being such that R2/Rt ranges from 1.02 to 1.25, with Rt being the helix radius of the theoretical outer layer (CET) obtained when the inner layer (CI) is in direct contact with the theoretical outer layer (CET), and a step (400) to bring the outer layer (CE) of the cable closer to the circle circumscribing the inner layer (CI) of the cable so that the ratio R2/Rt ranges from 1.00 to 1.10.

(57) **Abrégé :** L'invention concerne un câble (50) multi-torons à deux couches, comprenant : - une couche interne (CI) à deux couches (C1, C3) constituée de K≥1 toron(s) interne(s) (TI) et une couche externe (CE) constituée de L>1 torons externes (TE) à deux couches (C1', C3') enroulés autour de la couche interne (CI) présentant un rayon d'hélice R2. Les couches externes (C3, C3') de chaque toron interne et externe (TI, TE) sont désaturées. Le câble (50) est obtenu par un procédé comprenant une étape de fabrication de la couche interne gainée (CIG) dans laquelle on entoure la couche interne (CI) d'une composition élastomérique présentant une épaisseur G puis d'une couche externe (CE), G étant telle que R2/Rt va de 1,02 à 1,25 avec Rt étant le rayon d'hélice la couche externe théorique (CET) obtenue lorsque la couche

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interne (CI) est directement au contact de la couche externe théorique (CET) et une étape (400) pour rapprocher la couche externe (CE) du câble du cercle dans lequel la couche interne (CI) du câble est circonscrite de telle sorte à ce que le rapport R2/Rt va de 1,00 à 1,10.

TWO-LAYER MULTI-STRAND CORD HAVING A SHEATHED INNER LAYER AND IMPROVED PENETRABILITY

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

[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. This crown reinforcement comprises a plurality of plies made of elastomer composition, possibly reinforced with reinforcing elements such as cords or monofilaments, of the metal or textile type.

[003] 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.

[004] The crown reinforcement may also comprise various other auxiliary plies or layers of elastomer composition, 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.

[005] A working ply reinforcing element comprising a two-layer multi-strand metal cord as disclosed in the examples of WO2016051669 is known from the prior art. This cord comprises an internal layer of the cord made up of an internal strand and an external layer of the cord made up of seven external strands wound in a helix around the internal layer of the cord. The internal strand comprises an internal layer of the strand made up of two internal metal threads and an external layer of the strand made up of nine external metal threads. Further, each external strand comprises an internal layer of the strand made up of three internal metal threads and an external layer of the strand made up of eight external metal threads.

[006] A tyre of a heavy-duty 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 crown reinforcement, in particular of the crown plies, and considerably reduce the life of the tyre.

[007] 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 metal thread with an elastomer composition during the manufacture of the cord. During this process, the elastomer composition 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.

[008] 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 0.45 mm, as is the case in application WO2016051669, 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 composition to penetrate the strands. Finally, increasing the individual strength of each thread entails significant investment in the installations used to manufacture the threads.

[009] The object of the invention is a cord exhibiting improved penetrability of its external strands and better accessibility by the elastomer composition to the internal strand as compared with the cord of application WO2016051669, thus making it possible to reduce the ingress and spread of corrosive agents into and along the cord, without in so doing impairing the strength at break of the cord.

[010] **<u>CORD ACCORDING TO THE INVENTION</u>**

[011] 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 K≥1 internal strand(s), the or each internal strand being a two-layer strand and comprising:

- an internal layer made up of Q=2, 3 or 4 internal metallic threads, and

- an external layer made up of N external metallic threads of diameter d3 wound around the internal layer,

- an external layer of the cord made up of L>1 external strands wound around the internal layer of the cord, having a helix radius R2, each external strand being a two-layer strand and comprising:

- an internal layer made up of Q'=2, 3 or 4 internal metallic threads, and

- an external layer made up of N' external metallic threads of diameter d3' wound around the internal layer,

wherein:

- the external layer of the or each internal strand is desaturated so that the sum SI3 of the inter-thread distances I3 of the external layer of the or of each internal strand is greater than or equal to the diameter d3;

- the external layer of each external strand is desaturated so that the sum SI3' of the inter-thread distances I3' of the external layer of each external strand is greater than or equal to the diameter d3';

the cord is obtained by a method comprising:

- a step of manufacturing the sheathed internal layer in which step the internal layer is surrounded with an elastomer composition having a thickness G and then by an external layer, the thickness G of the elastomer composition being such that the ratio R2/Rt ranges from 1.06 to 1.25, where Rt is the helix radius of the theoretical external layer obtained when the internal layer is directly in contact with the theoretical external layer; and

- a step for bringing the external layer (CE) of the cord closer to the circle in which the internal layer (CI) of the cord is circumscribed so that the ratio R2/Rt ranges from 1.00 to 1.10.

[012] 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".

[013] By definition, the helix radius R2 of the external layer of the cord is the radius of the theoretical circle passing through the centres of the external strands of the external layer in a plane perpendicular to the axis of the cord.

[014] By definition, the diameter of a strand is the diameter of the smallest circle inside which the strand can be circumscribed.

[015] By definition, a desaturated layer of threads is one such that there is enough space left between the metal threads to allow a non-crosslinked elastomer composition to pass. According to the invention, the external layer of each strand is desaturated, which means that the metal threads of the external layer do not touch and that there is enough space between two adjacent external metal threads to allow an elastomer composition to pass, which is to say that the sum of the inter-thread distances is greater than or equal to the diameter of the thread. 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 of the inter-thread distances by the number of spaces between the threads in the layer. In other words, a layer may be desaturated when the inter-thread distance is greater than or equal to 5 µm.

[016] For preference, the inter-thread distance I3 of the external layer of the or each 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.

[017] For preference, the inter-thread distance I3’ 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.

[018] For preference, the inter-thread distance of the external layer of each strand is less than or equal to 100 µm.

[019] By contrast, a saturated layer of threads is such that there is not enough space between the metal threads to allow an elastomer composition to pass, which is to say such that the sum of the inter-thread distances is strictly less than the diameter of the thread.

[020] 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.

[021] What is meant by directly in contact with the theoretical external layer is that there is no sheath present between the internal layer and the theoretical external layer.

[022] What is meant by an elastomer composition or an elastomeric composition is that the composition contains at least one elastomer or one rubber (the two terms being synonyms) and at least one other component.

[023] The internal layer of the cord is surrounded by an elastomer composition of a thickness G and then surrounded by an external layer.

[024] The cord according to the invention offers improved penetrability by comparison with a cord from the examples of WO2011000963 which is not penetrated because of the absence of elastomer composition between the internal layer and the external layer. The inventors behind the invention are putting forward the hypothesis that having this initial ratio R2/Rt ranging from 1.02 to 1.25 makes it possible to have a sufficient thickness of elastomer composition to allow it to infiltrate the internal strand and fill the gaps. Furthermore, the desaturation of the external layers allows the elastomer composition to penetrate, on the one hand, between the external strands and, on the other hand, between the external strands and the internal strand(s), thus allowing the elastomer composition originating from the sheath to be driven into the internal strand or strands in order to penetrate the central capillary. Thus, with the aid of a final step that enables the external strands to be brought closer to the internal layer, the cord can thus be reduced in diameter while at the same time being very well penetrated.

[025] Advantageously, the or each internal strand has cylindrical layers.

[026] Advantageously, each external strand has cylindrical layers.

[027] Highly advantageously, the or each internal strand and each external strand have cylindrical layers. It will be recalled that such cylindrical layers are obtained when the various layers of a strand are wound at different pitches 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 which exhibits far lower penetrability.

[028] 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.

[029] 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.

[030] 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.

[031] For preference, the strands do not undergo pre-shaping.

[032] 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.

[033] When a carbon steel is advantageously used, its carbon content (% by weight of steel) is preferably between 0.05% and 1.2%, in particular between 0.4% and 1.1%; these contents represent a good compromise between the mechanical properties required for the tyre and the feasibility of the threads.

[034] 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 properties 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 the properties of adhesion, corrosion resistance or else resistance to ageing. According to a preferred embodiment, the steel used is covered with a layer of brass (Zn-Cu alloy) or of zinc.

[035] 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.

[036] 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.

[037] In a first embodiment according to the invention, the external layer of the cord is saturated.

[038] By definition, a saturated layer of cord is such that the inter-strand distance for the external strands is strictly less than 20 µm. The inter-strand distance of the external layer of external strands is 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. Thus, this construction of the cord makes it possible to ensure good architectural stability of the external layer and the saturation of the external layer makes it possible to ensure that the external layer comprises a relatively high number of external strands and therefore exhibits a relatively high force at break.

[039] By contrast, a desaturated layer of cord is such that the inter-strand distance for the external strands is greater than or equal to 20 µm.

[040] In a second embodiment according to the invention, L is less than or equal to the maximum number of external strands Lmax that can be laid on the theoretical external layer having a helix radius Rt and L is such that the external layer is incompletely unsaturated.

[041] By definition, a layer that is incompletely unsaturated is such that there is not enough space in this layer to add in at least one $(P+1)^{th}$ strand having the same diameter as the P 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. Thus, this construction of the cord makes it possible to ensure good architectural stability of the external layer and the incomplete non-saturation of the external layer makes it possible to ensure that the external layer comprises a relatively high number of external strands and therefore exhibits a relatively high force at break.

[042] A completely unsaturated layer is, as opposed to an incompletely unsaturated layer, such that there is sufficient space in this layer to add in at least one $(P+1)^{th}$ strand having the same diameter as the P 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 to add in at least one $(L+1)^{th}$ strand having the same diameter as the L external strands of the external layer.

[043] As a preference, L is equal to the maximum number of external strands Lmax that can be laid on the theoretical external layer having a helix radius Rt and L is such that the external layer is incompletely unsaturated. The external layer comprises a high number of external strands and therefore exhibits a relatively high force at break.

[044] Advantageously, the thickness G of the sheath of elastomer composition is strictly greater than 0 mm, and preferably greater than or equal to 0.01 mm. The greater the thickness G of the elastomer composition, the better the penetrability in the internal layer.

[045] Advantageously, the thickness G of the sheath of elastomer composition is less than or equal to 0.80 mm, preferably less than or equal to 0.60 mm, and more preferably less than or equal to 0.52 mm. This thickness makes it possible to optimize the penetrability of the internal layer while at the same time limiting the external diameter of the cord.

[046] Advantageously, the elastomer composition comprises an elastomer selected from the group consisting of polybutadienes, natural rubber, synthetic polyisoprenes, butadiene copolymers, isoprene copolymers and mixtures of these elastomers.

[047] Preferably, the elastomer composition comprises an elastomer selected from the group consisting of natural rubber, synthetic polyisoprenes, isoprene copolymers, and mixtures of these elastomers.

[048] For preference, the elastomer composition also contains a vulcanization system and a filler. More preferentially, the elastomer is a diene elastomer.

[049] As a preference, the elastomer composition contains carbon black as reinforcing filler.

[050] Advantageously, K=1, 2, 3 or 4, and preferably K=1, 2 or 3 and more preferably K=1 or 3.

[051] Advantageously, L=6, 7, 8, 9 or 10; and preferably L=6, 7, 8 or 9 and more preferably L=6 or 9.

[052] In a first variant, K=1, and L=6. In the cord in which K=1, the most severe transverse loadings are the transverse loadings exerted by the external strands on the internal strand. Here, the presence of the elastomer composition will make it possible to relieve the contact pressures on the internal strand by affording the latter good penetrability.

[053] In a second variant, K=2 and L=7 or 8, and preferably K=2 and L=8.

[054] In a third variant, K=3 and L=7, 8 or 9, and preferably K=3, L=9.

[055] In a fourth variant, K=4 and L=7, 8, 9 or 10, and preferably K=4, L=9 or 10.

[056] In embodiments not in accordance with the invention, notably those in which K=3 or 4, there is a risk of seeing a very significant spread of corrosive agents between the K=3 or 4 internal strands which delimit a central capillary which very much encourages them to spread along the cord, when the cord is insufficiently penetrated. This disadvantage can be overcome by virtue of the sheath around the K internal strands rendering it penetrable by the elastomer composition thus preventing corrosive agents from accessing the central capillary, which is itself penetrated, and prevents these corrosive agents from spreading along the cord.

[057] In cords in which K>1, the most severe transverse loadings applied to the cord when the latter is tensioned are the transverse loadings applied between the internal strands. Cords exhibiting an architecture in which K>1 and comprising a number of external strands such that the external layer of the cord is saturated so as to maximize the breaking strength by adding a maximum number of external strands are known from the prior art. Here, thanks to the fact that the external layers of the strands are desaturated, the cord has, on the one hand, spaces between the external threads that allow the elastomer composition to pass, therefore allowing the cord to be rendered less sensitive to corrosion. On the other hand, although the number of external threads is reduced, the desaturation of the external layer of the strands allows the elastomer composition, on the one hand, to penetrate between the external threads and, on the other hand, makes it possible to push the elastomer composition of the sheath between the internal strands so as to form a cushion of elastomer composition that at least partially absorbs the transverse loads applied between the internal strands. Thus, by comparison with a similar cord having a saturated external layer of the cord, a better corrosion resistance is achieved.

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

[059] In one preferred embodiment, Q>1, for preference Q=2, 3 or 4. In instances in which Q is equal to 1, there would be 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. Thanks to the presence of several threads in the internal layer of the internal strand (Q>1), this risk is reduced, the compressive loadings then being distributed over the plurality of threads of the internal layer.

[060] Advantageously, N=7, 8, 9 or 10.

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

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

[063] In a third alternative form, Q=4 and N=7, 8, 9 or 10, for preference Q=4, N=9.

[064] Highly advantageously, each internal thread of the internal strand has a diameter d1 equal to the diameter d3 of each external thread of the internal strand. Thus, the same diameter of thread is preferably used in the internal and external layers of the internal strand, thereby limiting the number of different threads that need to be managed during the manufacture of the cord.

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

[066] Advantageously, N'=7, 8, 9 or 10.

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

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

[069] In a third alternative form, Q'=4 and N'=7, 8, 9 or 10, for preference Q'=4, N'=9.

[070] Highly advantageously, each internal thread of the external strand has a diameter d1' equal to the diameter d3' of each external thread of the external strand. Thus, the same diameter of thread is preferably used in the internal and external layers of the external strand, thereby limiting the number of different threads that need to be managed during the manufacture of the cord.

[071] Advantageously,

- Q=3, and N=8,

- each internal metal thread of each internal strand has a diameter d1 equal to the diameter d3 of each external thread of each internal strand,

- Q'= 3 and N'=8,

- each internal metal thread of each external strand has a diameter d1' equal to the diameter d3' of each external thread of each external strand, and

- d1=d3=d1'=d3'.

[072] Advantageously, each metallic thread has a respective diameter d1, d1', d3, d3' ranging from 0.10 mm to 0.60 mm, preferably from 0.12 mm to 0.50 mm and more preferentially from 0.15 mm to 0.42 mm.

[073] **METHOD FOR MANUFACTURING THE CORD ACCORDING TO THE INVENTION**

[074] Another subject of the invention is a method for manufacturing a two-layer multi-strand cord, wherein:

- in a step, K≥1 internal strand(s) are assembled by cabling or twisting into a helix to form an internal layer of the cord; the or each internal strand being a two-layer strand and comprising: an internal layer made up of Q=2, 3 or 4 internal metallic threads, and an external layer made up of N external metallic threads of diameter d3 wound around the internal layer, so that the sum SI3 of the inter-thread distances I3 of the external layer of the or of each internal strand is greater than or equal to the diameter d3;

- in a step, the internal layer is surrounded with an elastomer composition having a thickness G, to form a sheathed internal layer, the thickness G of the elastomer composition being such that the ratio R2/Rt ranges from 1.02 to 1.25, where Rt is the helix radius of the theoretical external layer obtained when the internal layer is directly in contact with the theoretical external layer;

- in a step, L>1 external strands are assembled by cabling or twisting into a helix around the internal layer of the cord; each external strand being a two-layer strand and comprising: an internal layer made up of Q'=2, 3 or 4 internal metallic threads, and an external layer made up of N' external metallic threads of diameter d3' wound around the internal layer, so that the sum SI3' of the inter-thread distances I3' of the external layer of each external strand is greater than or equal to the diameter d3';

- in a step, means are used for bringing the external layer of the cord closer to the circle in which the internal layer of the cord is circumscribed so that the ratio R2/Rt ranges from 1.00 to 1.10.

[075] Advantageously, the steps of assembling the K≥1 internal strands into a helix and of assembling the L>1 external strands around the internal layer of the cord are performed using cabling.

[076] Advantageously, the means employed for bringing the external layer of the cord closer to the circle in which the internal layer of the cord is circumscribed consist, for example, of two rows of rollers mounted facing one another but with an offset and between which the cord is passed.

[077] In one embodiment, one of the rows is mobile and can be brought closer to the fixed row so that the cable experiences a succession of bendings.

[078] In another embodiment, the rows of rollers are able to move about the axis of the cord.

[079] **<u>REINFORCED PRODUCT ACCORDING TO THE INVENTION</u>**

[080] Another subject of the invention is a reinforced product comprising an elastomer matrix and at least one cord as defined above.

[081] Advantageously, the reinforced product comprises one or several cords according to the invention embedded in the elastomer matrix and, in the case of several cords, the cords are arranged side-by-side in a main direction.

[082] **<u>TYRE ACCORDING TO THE INVENTION</u>**

[083] Another subject of the invention is a tyre comprising at least one cord or a reinforced product as defined above.

[084] For preference, 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.

[085] In one preferred embodiment, the crown reinforcement comprises a protective reinforcement and a working reinforcement, the working reinforcement comprising at least one cord as defined hereinabove, the protective reinforcement being interposed radially between the tread and the working reinforcement.

[086] 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.

[087] As a preference, the tyre is for a vehicle of the construction plant type. Thus, the tyre has a size in which the diameter, in inches, of the seat of the rim on which the tyre is intended to be mounted is greater than or equal to 40 inches.

[088] A better understanding of the invention will be obtained on reading the examples which will follow, given solely by way of non-limiting examples and made 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;

- Figure 3 is a view in cross section of a reinforced product according to the invention;

- Figure 4 is a schematic view in cross section perpendicular to the axis of the cord (which is assumed to be straight and at rest) of a cord (50) according to a first embodiment of the invention;

- Figure 5 is a view similar to that of Figure 4 of a cord (60) according to a second embodiment of the invention;

- Figure 6 is a view similar to that of Figure 4 of a cord (70) according to a third embodiment of the invention;

- Figure 7 is a view similar to that of Figure 4 of a cord (80) according to a fourth embodiment of the invention;

- Figures 8 and 9 are schematic depictions of an installation for the manufacture of a cord

(50) according to a first embodiment of the invention;

- Figure 10 is a schematic depiction of the step 400 of moving the external layer closer to the internal layer of a cord (50) according to a first embodiment of the invention; and

- Figure 11 is a photograph of a control cord (T1) and of a cord (50) according to a first embodiment of the invention.

[089] EXAMPLE OF A TYRE ACCORDING TO THE INVENTION

[090] 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 Figures 1 and 2.

[091] The “median circumferential plane” M of the tyre is the plane that is normal to the axis of rotation of the tyre and that is located equidistantly from the annular reinforcement structures of each bead.

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

[093] 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.

[094] 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 wire 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 wires 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.

[095] The carcass reinforcement 24 comprises at least one carcass ply 30 reinforced by radial carcass cords (not depicted). The carcass cords are positioned substantially parallel to one another and extend from one bead 18 to the other so as to form an angle comprised between 80° and 90° with the median circumferential plane M (plane perpendicular to the axis of rotation of the tyre which is situated midway between the two beads 18 and passes through the middle of the crown reinforcement 14).

[096] 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.

[097] 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 40 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 40.

[098] The protective reinforcement 36 comprises first and second protective plies 42, 44 comprising protective metal cords, the first ply 42 being arranged radially on the inside of the second ply 44. Optionally, the protective metal cords make 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.

[099] 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 ply 46, 48 comprises at least one cord 50. Optionally, the working metal cords 50 are crossed from one working ply to the other and make an angle at most equal to 60°, preferably in the range from 15° to 40°, with the circumferential direction Z of the tyre.

[0100] The additional reinforcement 40, also referred to as a limiting block, the purpose of which is to absorb in part the mechanical stresses of inflation, comprises, for example and as known per se, additional metallic reinforcing elements, for example as described in FR 2 419 181 or FR 2 419 182, making an angle at most equal to 10°, preferably in the range from 5° to 10°, with the circumferential direction Z of the tyre 10.

[0101] EXAMPLE OF A REINFORCED PRODUCT ACCORDING TO THE INVENTION

[0102] Figure 3 depicts a reinforced product according to the invention and denoted by the general reference 100. The reinforced product 100 comprises at least one cord 50, in this instance several cords 50, embedded in the elastomer matrix 102.

[0103] Figure 3 depicts the elastomer matrix 102, the cords 50 in a frame of reference X, Y, Z, in which the direction Y is the radial direction and the directions X and Z are the axial and circumferential directions. In Figure 3, the reinforced product 100 comprises several cords 50 arranged side-by-side in the main direction X and extending parallel to one another within the reinforced product 100 and collectively embedded in the elastomer matrix 102.

[0104] CORD ACCORDING TO A FIRST EMBODIMENT OF THE INVENTION

[0105] Figure 4 depicts the cord 50 according to a first embodiment of the invention. The cord 50 is depicted before the step 400 of bringing the external layer CE of the cord closer to the circle inside which the internal layer CI of the cord is circumscribed.

[0106] The cord 50 is metal and is 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.

[0107] The cord 50 comprises an internal layer CI of the cord which is made up of K≥1 internal strand(s) TI. In this particular instance, K=1, 2, 3 or 4, and preferably K=1, 2 or 3 and more preferably K=1 or 3; here, K=3. The internal layer CI is surrounded by an elastomer composition of a thickness G thus forming the sheathed internal layer CIG. The external layer CE is made up of L>1 external strands TE wound around the sheathed internal layer CIG of the cord with a helix radius R2. In this particular instance, L=6, 7, 8, 9 or 10; and preferably L=6, 7, 8 or 9 and more preferably L=6 or 9, and in this particular instance L=9. Here, R2 is equal to 2.50 mm.

[0108] The thickness G of the elastomer composition is such that the ratio R2/Rt ranges from 1.02 to 1.25, where Rt is the helix radius of the theoretical external layer CET obtained when the internal layer CI is directly in contact with the theoretical external layer CET. Here, R2= 2.40 and R2/Rt = 2.40/2.28= 1.05.

[0109] The cord 50 is finally obtained by a method comprising a step 500 for bringing the external layer CE of the cord closer to the circle in which the internal layer CI of the cord is circumscribed so that the ratio R2/Rt ranges from 1.00 to 1.10. Here, R2=2.32 and R2/Rt=2.33/2.28=1.02.

[0110] The cord 50 also comprises a wrapper F (not depicted) made up of a single wrapping wire.

[0111] <u>Internal strands TI of the cord 50</u>

[0112] Each internal strand TI is a two-layer strand and comprises an internal layer C1 made up of Q= 2, 3 or 4 internal metallic threads F1 and an external layer C3 made up of N external metallic threads F3 wound around the internal layer C1.

[0113] Here, Q=3.

[0114] N=7, 8, 9 or 10, and here N=8.

[0115] The external layer C3 of each internal strand TI is desaturated and is incompletely unsaturated. Because it is desaturated, the inter-thread distance of the external layer of each 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 and is here equal to 66 μm. The sum SI3 of the inter-thread distances I3 of the external layer of each internal strand is greater than or equal to the diameter d3 of the external threads of the external layer of each internal strand. Here, the sum SI3=0.53 mm, a value which is greater than d3=0.35 mm.

[0116] Each internal and external thread of each internal strand TI respectively has a diameter d1 and d3. Each internal thread diameter d1 and external thread diameter d3 of each internal strand TI ranges from 0.10 mm to 0.60 mm, preferably from 0.12 mm to 0.50 mm, more preferably from 0.14 mm to 0.42 mm. Here, d1=d3=0.35 mm.

[0117] <u>External strands TE of the cord 50</u>

[0118] Each external strand TE has two layers and comprises an internal layer C1' made up of Q'= 2, 3 or 4 internal metallic threads F1' and an external layer C3' made up of N' external metallic threads F3' wound around the internal layer C1'.

[0119] Here, Q'=3.

[0120] N'=7, 8, 9 or 10, and here N'=8.

[0121] The external layer C3' of each external strand TE is desaturated. Because it is desaturated, the inter-thread distance I3' of the external layer C3' that on average separates the N' external threads is greater or 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 and is here equal to 66 μm. The sum SI3' of the inter-thread distances I3' of the external layer of each external strand is greater than or equal to the diameter d3 of the external threads of the external layer of each external strand. Here, the sum SI3'=0.53 mm, a value which is greater than d3'=0.35 mm.

[0122] Each internal and external thread of each external strand TE respectively has a diameter d1' and d3'. Each internal thread diameter d1' and external thread diameter d3' of each external strand TE ranges from 0.10 mm to 0.60 mm, preferably from 0.12 mm to 0.50 mm and more preferably from 0.14 mm to 0.42 mm. Here, d1'=d3'=0.35 mm.

[0123] The cord 50 is such that Q=3 and N=8, each internal metallic thread F1 of each internal strand TI has a diameter d1 equal to the diameter d3 of each external thread F3 of each internal strand TI; Q'=3 and N'=8, each internal metallic thread of each external strand TE has a diameter d1' equal to the diameter d3' of each external thread of each external strand TE; and d1=d3=d1'=d3'. Here, d1=d3=d1'=d3'=0.35 mm.

[0124] The external layer CE of the cord is desaturated. The mean inter-strand distance E separating two adjacent external strands TE is therefore greater than or equal to 20 µm. As a preference, the mean inter-strand distance E separating two adjacent external strands TE is greater than or equal to 40 µm and more preferably greater than or equal to 50 µm. Here, the inter-strand distance E is equal to 125 µm.

[0125] Each thread has a breaking strength, denoted Rm, such that 2500 ≤ Rm ≤ 3100 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.

[0126] METHOD FOR MANUFACTURING THE CORD ACCORDING TO THE INVENTION

[0127] An example of a method for the manufacture of the multi-strand cord 50 will now be described with reference to Figures 8 and 9.

[0128] Each aforementioned internal strand is manufactured according to known methods involving the following steps, preferably performed in line and continuously:

- first of all, a first step of assembling, by cabling, the Q=2, 3 or 4 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 N external threads F3 around the Q internal threads F1 of the internal layer C1 at the pitch p3 and in the Z-direction to form the external layer C3 at a second assembling point;

- preferably a final twist-balancing step.

[0129] In a step 100, K≥1 internal strands TI are assembled by cabling into a helix to form an internal layer CI of the cord.

[0130] In a step 200, the internal layer CI is surrounded with an elastomer composition having a thickness G, to form a sheathed internal layer CIG, the thickness G of the elastomer composition being such that the ratio R2/Rt ranges from 1.02 to 1.25, where Rt is the helix radius of the theoretical external layer CET obtained when the internal layer CI is directly in contact with the theoretical external layer CET.

[0131] Each aforementioned external strand is manufactured according to known methods involving the following steps, preferably performed in line and continuously:

- first of all, a first step of assembling, by cabling, the Q'=2, 3 or 4 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 N' external threads F3' around the Q' internal threads F1' of the internal layer C1' at the pitch p3' and in the Z-direction to form the external layer C3' at a second assembling point;

- preferably a final twist-balancing step.

[0132] 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.

[0133] 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.

[0134] In a step 300, L>1 external strands TE are assembled by cabling into a helix around the internal layer CI of the cord. In a step 400, means 500 are used for bringing the external layer CE of the cord closer to the circle in which the internal layer CI of the cord is circumscribed so that the ratio R2/Rt ranges from 1.00 to 1.10.

[0135] This step 400 is described with reference to Figure 10.

[0136] The means 500 employed for bringing the external layer CE of the cord closer to the circle in which the internal layer CI of the cord is circumscribed consist, for example, of two rows of rollers mounted facing one another but with an offset and between which the cord is passed. Each row contains between 6 and 8 rollers. One of the rows is mobile and can be brought closer to the fixed row so that the cord experiences a succession of bendings. These rows of rollers may be fixed or able to move about the axis of the cord.

[0137] Thus, the cord experiences a succession of bending operations able to reduce its diameter as illustrated in Figure 10.

[0138] L is equal to the maximum number of external strands (TE) Lmax that can be laid on the theoretical external layer (CET) having a helix radius Rt and L is such that the external layer (CE) is incompletely unsaturated. Here, Lmax=9 and L=Lmax=9.

[0139] The thickness G of the sheath of an elastomer composition is strictly greater than 0 mm, preferably greater than or equal to 0.01 mm, and the thickness G is less than or equal to 0.80 mm, preferably less than or equal to 0.60 mm, and more preferably less than or equal to 0.52 mm. Here, G=0.05 mm.

[0140] The elastomer composition contains a vulcanization system, a filler and a diene elastomer.

[0141] The elastomer composition used is a diene elastomer composition 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 composition is around 10 MPa.

[0142] Possibly, in a last assembly step, the wrapper F is wound, at the pitch pf and in the S-direction, around the assembly previously obtained.

[0143] 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 composition 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).

[0144] The composite fabrics reinforced by these cords have an elastomer composition matrix formed from two thin layers of elastomer composition which are superposed on either side of the cords and which have a thickness ranging between 1 and 4 mm, respectively. The skim pitch (spacing at which the cords are laid in the elastomer composition fabric) ranges from 4 mm to 8 mm.

[0145] 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.

[0146] CORD ACCORDING TO A SECOND EMBODIMENT OF THE INVENTION

[0147] Figure 5 depicts a cord 60 according to a second embodiment of the invention. The cord 60 is depicted before the step 400 of bringing the external layer CE of the cord closer to the circle inside which the internal layer CI of the cord is circumscribed. Elements similar to those of the first embodiment are denoted by identical references.

[0148] Unlike in the first embodiment described hereinabove, the cord 60 according to the second embodiment is such that K=1 and L=6.

[0149] CORD ACCORDING TO A THIRD EMBODIMENT OF THE INVENTION

[0150] Figure 6 depicts a cord 70 according to a third embodiment of the invention after the step 400 of bringing the external layer CE of the cord closer to the circle inside which the internal layer CI of the cord is circumscribed.

[0151] Unlike in the first embodiment of the cord 50 described hereinabove, the cord 70 according to the third embodiment is such that K=2 and L=9.

[0152] CORD ACCORDING TO A FOURTH EMBODIMENT OF THE INVENTION

[0153] Figure 7 depicts a cord 80 according to a fourth embodiment of the invention after the step 400 of bringing the external layer CE of the cord closer to the circle inside which the internal layer CI of the cord is circumscribed.

[0154] Unlike in the first embodiment of the cord 50 described hereinabove, the cord 80 according to the fourth embodiment is such that K=4 and L=10.

[0155] Table 1 below summarizes the characteristics of the various cords 50, 51, 60, 70 and 80.

Table 1

Cords		50	60	70	80	51
TI	Q/N	3/8	3/8	3/8	3/8	3/8
	d1/d3	0.35/0.35	0.35/0.35	0.35/0.35	0.35/0.35	0.35/0.35
	direction for C1/pitch p1 (mm)	Z/7.7	Z/7.7	Z/7.7	Z/7.7	Z/7.7
	direction for C3/pitch p3 (mm)	Z/15.4	Z/15.4	Z/15.4	Z/15.4	Z/15.4

	I3(μm)/SI3(mm)	66/0.53	66/0.53	66/0.53	66/0.53	66/0.53
Sheath	G (mm)	0.05	0.11	0.06	0.08	0.01
TE	Q'/N'	3/8	3/8	3/8	3/8	3/8
	d1'/d3'	0.35/0.35	0.35/0.35	0.35/0.35	0.35/0.35	0.35/0.35
	direction for C1'/pitch p1' (mm)	Z/7.7	Z/7.7	Z/7.7	Z/7.7	Z/7.7
	direction for C3'/pitch p3' (mm)	Z/15.4	Z/15.4	Z/15.4	Z/15.4	Z/15.4
	I3'(μm)/SI3'(mm)	66/0.53	66/0.53	66/0.53	66/0.53	66/0.53
Direction of cord/pi/pe		S/S 40/80	S/inf/60	S/S 40/80	S/S 40/80	S/S 40/80
K		3	1	2	4	3
L		9	6	9	10	9
Lmax		9	6	9	10	9
D (mm)		6.11	4.59	5.91	6.57	6.04
E (μm)		125	112	58	59	98
R2 before step 400		2.40	1.59	2.23	2.48	2.40
R2 after step 400		2.33	1.57	2.23	2.48	2.30
Rt		2.28	1.46	2.17	2.48	2.28
R2/Rt before step 400		1.05	1.09	1.03	1.03	1.05
R2/Rt after step 400		1.02	1.08	1.03	1.03	1.00

[0156] COMPARATIVE TESTS

[0157] AIR PERMEABILITY TEST

[0158] This test makes it possible to determine the longitudinal permeability to air of the cords tested, by measuring the volume of air that passes through a test specimen under constant pressure in a given time. The principle of such a test, which is well known to a person 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 the standard ASTM D2692-98.

[0159] 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 composition referred to as coating composition. 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 composition 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.

[0160] The composition used as a coating elastomer composition is a diene elastomer composition 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 composition is around 10 MPa.

[0161] The test is carried out on a 6 cm length of cord, which is therefore coated with its surrounding elastomer composition (or coating elastomer composition) 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 cm^3/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-composition test specimen, that is to say one devoid of cord.

[0162] The higher the longitudinal impermeability of the cord, the lower the mean air flow rate measured (averaged over the 10 test specimens). Since the measurement is carried out with an accuracy of ± 0.2 cm^3/min, measured values of less than or equal to 0.2 cm^3/min are regarded as zero; they correspond to a cord which can be described as airtight (completely airtight) along its axis (i.e. in its longitudinal direction).

[0163] Table 2 summarizes the characteristics of the control cords T1 and T2 and of the cord of the prior art EDT (Example 3 from WO2016051669).

[0164] Table 2

Cords		T1	T2	EDT
TI	Q/N	3/8	3/8	2/9
	d1/d3	0.35/0.35	0.35/0.35	0.48/0.48
	direction for C1/pitch p1 (mm)	Z/7.7	Z/7.7	Z/7.7
	direction for C3/pitch p3 (mm)	Z/15.4	Z/15.4	Z/15.4
	I3(µm)/SI3(mm)	66/0.53	66/0.53	0
Sheath	G (mm)	0	0	0
TE	Q'/N'	3/8	3/8	3/8
	d1'/d3'	0.35/0.35	0.35/0.35	0.28/0.37
	direction for C1'/pitch p1' (mm)	Z/7.7	Z/7.7	Z/7.7
	direction for C3'/pitch p3' (mm)	Z/15.4	Z/15.4	Z/15.4
	I3'(µm)/SI3'(mm)	66/0.53	66/0.53	0
K		3	4	1
L		9	10	6
Lmax		9	10	6
D (mm)		6.02	6.40	4.60
E (µm)		95	59	70

R2	2.28	2.48	1.64
Rt	2.28	2.48	1.64
R2/Rt	1.00	1.00	1.00

[0165] Tables 3 to 5 below summarize the results of the permeability test for, respectively, the various control cords T1 and T2, the cord of the prior art EDT and the cords according to the invention 50, 60 and 80. The results of these tests are indicated in base 100. Thus, a result of 100 for any one of these tests indicates that the cord tested exhibits maximum penetrability, which is to say that the cord is completely airtight.

[0166] Table 3

Cords	T1	50	50-1	50-2	50-3
K/L	3/9	3/9	3/9	3/9	3/9
Q/N/Q'/N'	3/8/3/8	3/8/3/8	3/8/3/8	3/8/3/8	3/8/3/8
R2 before step 400 (mm)	2.28	2.40	2.45	2.57	2.62
R2 after step 400 (mm)	-	2.32	2.35	2.47	2.42
Rt (mm)	2.28	2.28	2.28	2.28	2.28
R2/Rt before step 400	1	1.05	1.07	1.13	1.15
R2/Rt after step 400	1	1.02	1.03	1.08	1.06
G (mm)	0	0.04	0.07	0.19	0.14
Penetrability (base 100 cord 100% penetrated)	0	96	97	97	97

[0167] Table 4

Cords	EDT	60
K/L	1/6	1/6
Q/N/Q'/N'	2/9/3/8	3/8/3/8
R2 before step 400 (mm)	1.64	1.59
R2 after step 400 (mm)	-	1.57

Rt (mm)	1.64	1.46
R2/Rt before step 400	1	1.09
R2/Rt after step 400	-	1.08
G (mm)	0	0.11
Penetrability (base 100 cord 100% penetrated)	95	98

[0168] Table 5

Cords	T2	80	80-1
K/L	4/10	4/10	4/10
Q/N/Q'/N'	3/8/3/8	3/8/3/8	3/8/3/8
R2 before step 400 (mm)	2.48	2.56	2.63
R2 after step 400 (mm)	-	2.56	2.63
Rt (mm)	2.48	2.48	2.48
R2/Rt before step 400	1	1.03	1.06
R2/Rt after step 400	-	1.03	1.06
G (mm)	0	0.08	0.15
Penetrability (base 100 cord 100% penetrated)	0	91	95

[0169] It may be noted that the cords 50 according to the invention exhibit penetrability markedly better than that of the control cord T1 and therefore penetrability close to 100%, this being solely as a result of the ratio R2/Rt according to the invention. It may be further noted in Figure 11 that the central capillary is fully penetrated in the case of the cord 50 whereas that of T1 is not, the arrows indicating the regions in which elastomer composition is lacking.

[0170] Likewise, the cord 60 according to the invention exhibits penetrability greater than that of the cord of the prior art EDT.

[0171] Likewise, the cord 80 according to the invention exhibits penetrability markedly greater than that of the control cord than that of the control cord T2.

[0172] Thus, Tables 3 to 5 show that, for varying cord constructions, the penetration of the elastomer composition into the cord, and therefore the ability this elastomer composition has to access the internal strand, is significantly improved for a ratio R2/Rt according to the invention by virtue of the presence of the sheath of thickness G by comparison with the control cords for which R2/Rt=1.

[0173] Of course, the invention is not restricted to the exemplary embodiments described above.

[0174] 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.

[0175] 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.

CLAIMS

1. Two-layer multi-strand cord (50), **characterized in that** it comprises:

- an internal layer (CI) of the cord made up of K≥1 internal strand(s) (TI), the or each internal strand (TI) being a two-layer (C1, C3) strand and comprising:

- an internal layer (C1) made up of Q= 2, 3 or 4 internal metallic threads (F1), and
- an external layer (C3) made up of N external metallic threads (F3) of diameter d3 wound around the internal layer (C1),

- an external layer (CE) of the cord made up of L>1 external strands (TE) wound around the internal layer (CI) of the cord, having a helix radius R2, each external strand (TE) being a two-layer (C1', C3') strand and comprising:

- an internal layer (C1') made up of Q'=2, 3 or 4 internal metallic threads (F1'), and
- an external layer (C3') made up of N' external metallic threads (F3') of diameter d3' wound around the internal layer (C1'),

wherein:

- the external layer (C3) of the or of each internal strand (TI) is desaturated so that the sum SI3 of the inter-thread distances I3 of the external layer of the or of each internal strand (TI) is greater than or equal to the diameter d3;

- the external layer (C3') of each external strand (TE) is desaturated so that the sum SI3' of the inter-thread distances I3' of the external layer (C3') of each external strand (TE) is greater than or equal to the diameter d3';

- the cord (50) is obtained by a method comprising:

- a step of manufacturing the sheathed internal layer (CIG) in which step the internal layer (CI) is surrounded with an elastomer composition having a thickness G and then by an external layer (CE), the thickness G of the elastomer composition being such that the ratio R2/Rt ranges from 1.02 to 1.25, where Rt is the helix radius of the theoretical external layer (CET) obtained when the internal layer (CI) is directly in contact with the theoretical external layer (CET); and

- a step (400) for bringing the external layer (CE) of the cord closer to the circle in which the internal layer (CI) of the cord is circumscribed so that the ratio R2/Rt ranges from 1.00 to 1.10.

2. Cord (50) according to Claim 1, wherein the external layer (CE) of the cord is saturated so that the inter-strand distance of the external strands, defined, on a cross section of the cord perpendicular to the main axis of the cord (50), as being the shortest distance separating, on average, the circular envelopes in which two adjacent external strands (TE) are inscribed, is strictly less than 20 µm.

3. Cord (50) according to Claim 1, wherein L is equal to the maximum number of external strands (TE) Lmax that can be laid on the theoretical external layer (CET) having a helix radius Rt and L is such that the external layer (CE) is incompletely unsaturated.

4. Cord (50) according to any one of the preceding claims, in which the thickness G of the sheath of elastomer composition is strictly greater than 0 mm, and preferably greater than or equal to 0.01 mm.

5. Cord (50) according to any one of the preceding claims, wherein the thickness G of the sheath of elastomer composition is less than or equal to 0.80 mm, preferably less than or equal to 0.60 mm, and more preferably less than or equal to 0.52 mm.

6. Cord (50) according to any one of the preceding claims, wherein the elastomer composition comprises an elastomer selected from the group consisting of polybutadienes, natural rubber, synthetic polyisoprenes, butadiene copolymers, isoprene copolymers, and mixtures of these elastomers.

7. Cord (50) according to any one of the preceding claims, wherein K=1, 2, 3 or 4, and preferably K=1, 2 or 3 and more preferably K=1 or 3.

8. Cord (50) according to any one of the preceding claims, wherein L=6, 7, 8, 9 or 10 and preferably L=6, 7, 8 or 9 and more preferably L=6 or 9.

9. Cord (50) according to any one of the preceding claims, wherein N=7, 8, 9 or 10.

10. Cord (50) according to any one of the preceding claims, wherein N'=7, 8, 9 or 10.

11. Method of manufacturing a two-layer multi-strand cord (50), **characterized in that**:

- in a step (100), K≥1 internal strand(s) (TI), are assembled by cabling or twisting into a helix to form an internal layer (CI) of the cord; the or each internal strand (TI) being a two-layer (C1, C3) strand and comprising: an internal layer (C1) made up of Q= 2, 3 or 4 internal metallic threads (F1), and an external layer (C3) made up of N external metallic threads (F3) of diameter d3 wound around the internal layer (C1), so that the sum SI3 of the inter-thread distances I3 of the external layer of the or of each internal strand (TI) is greater than or equal to the diameter d3;

- in a step (200), the internal layer (CI) is surrounded with an elastomer composition having a thickness G, to form a sheathed internal layer (CIG), the thickness G of the elastomer composition being such that the ratio R2/Rt ranges from 1.02 to 1.25, where Rt is the helix radius of the theoretical external layer (CET) obtained when the internal layer (CI) is directly in contact with the theoretical external layer (CET);

- in a step (300), L>1 external strands (TE) are assembled by cabling or twisting into a helix around the internal layer (CI) of the cord, each external strand (TE) being a two-layer (C1', C3') strand and comprising: an internal layer (C1') made up of Q'=2, 3 or 4 internal metallic threads (F1'), and an external layer (C3') made up of N' external metallic threads (F3') of diameter d3' wound around the internal layer (C1'), so that the sum SI3' of the inter-thread distances I3' of the external layer (C3') of each external strand (TE) is greater than or equal to the diameter d3';

- in a step (400), means (500) are used for bringing the external layer (CE) of the cord closer to the circle in which the internal layer (CI) of the cord is circumscribed so that the ratio R2/Rt ranges from 1.00 to 1.10.

12. Reinforced product (100), **characterized in that** it comprises an elastomer matrix (102) and at least one cord (50) according to any one of Claims 1 to 10.

13. Tyre (10), **characterized in that** it comprises at least one cord (50) according to any one of Claims 1 to 10 or a reinforced product according to Claim 12.

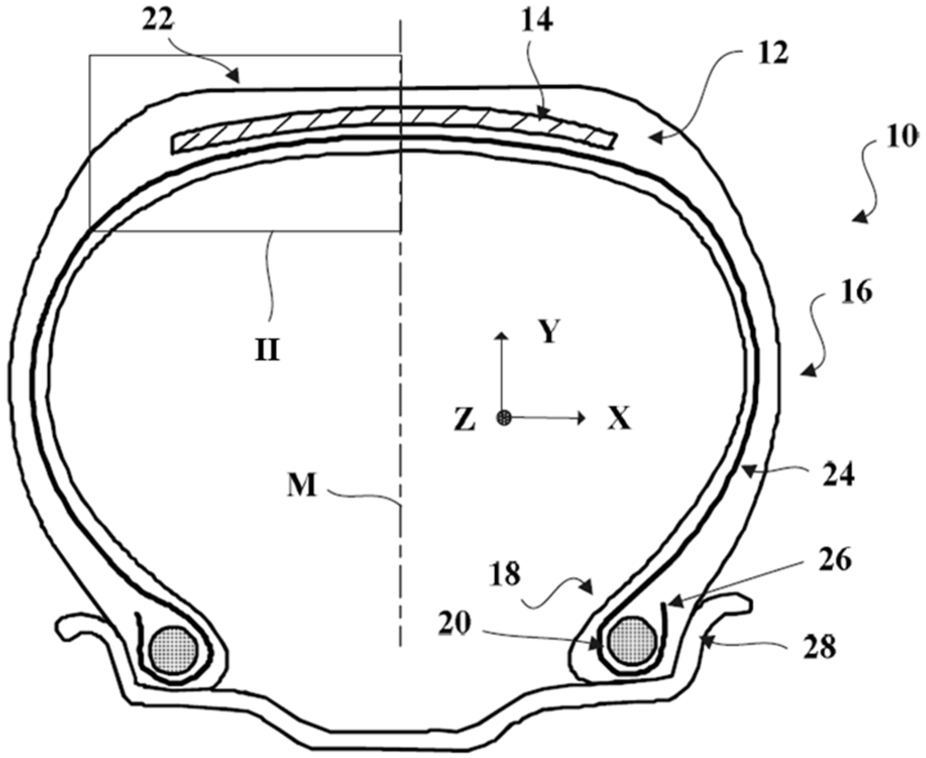


Fig.1

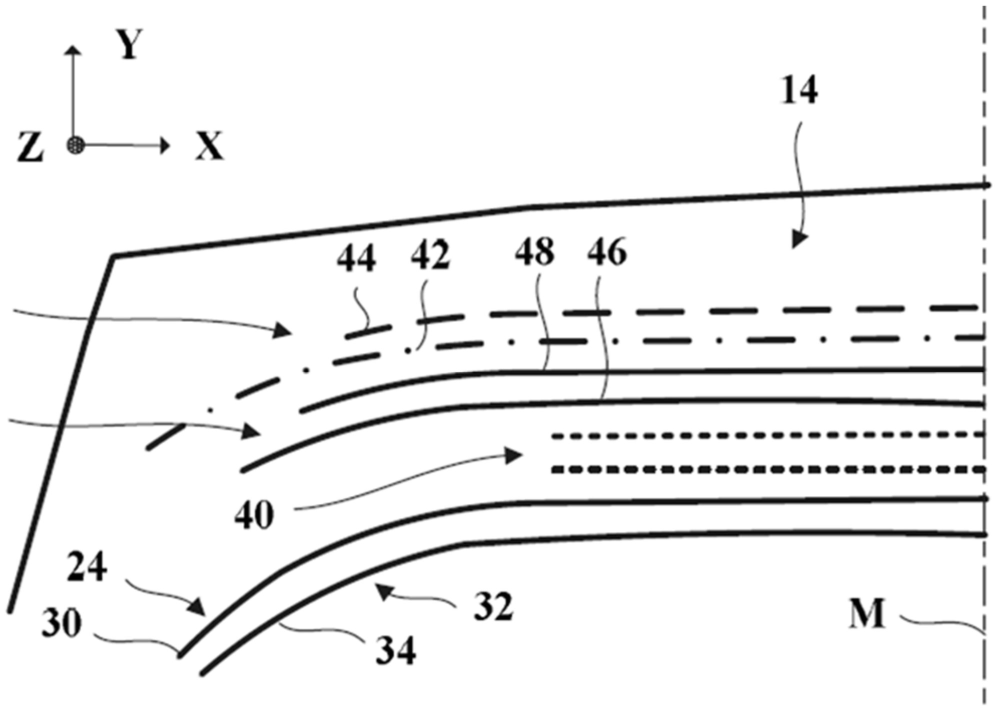


Fig.2

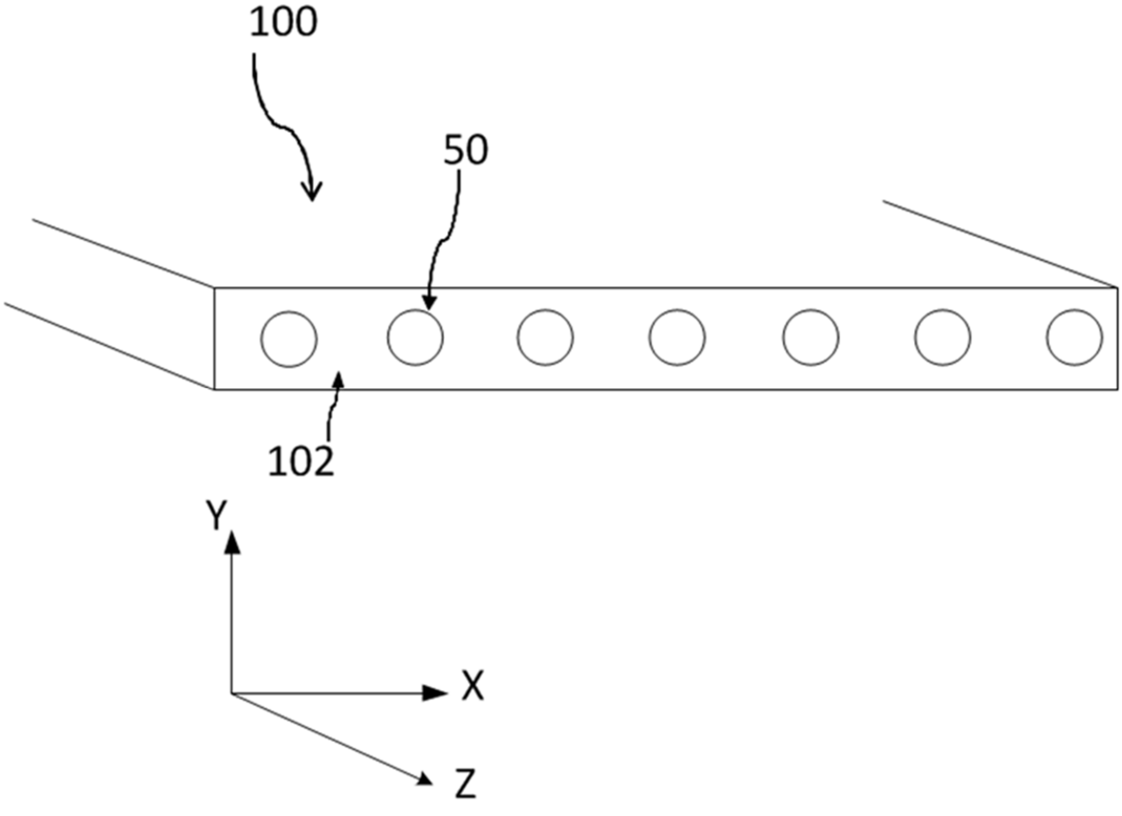


Fig.3

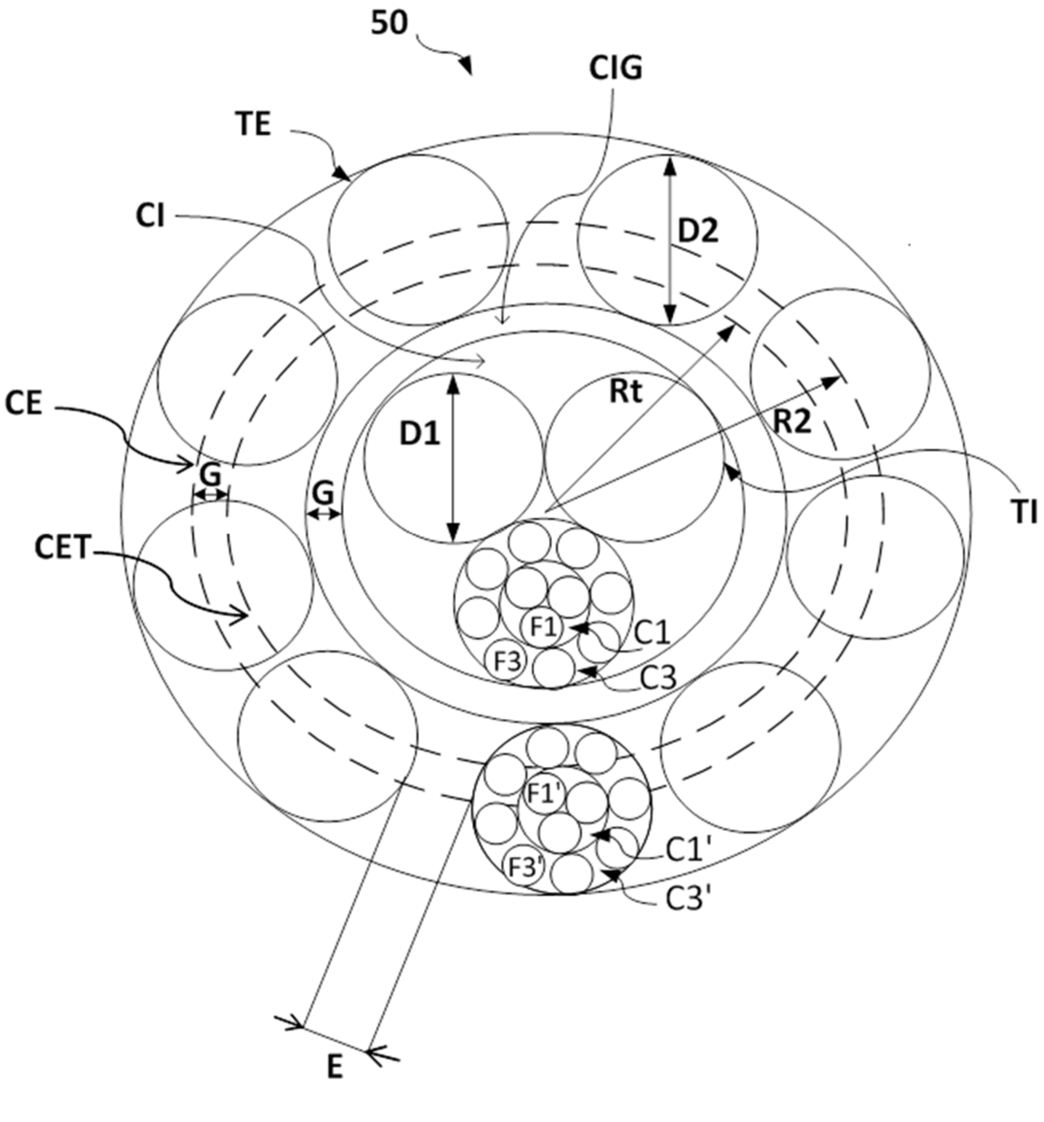


Fig.4

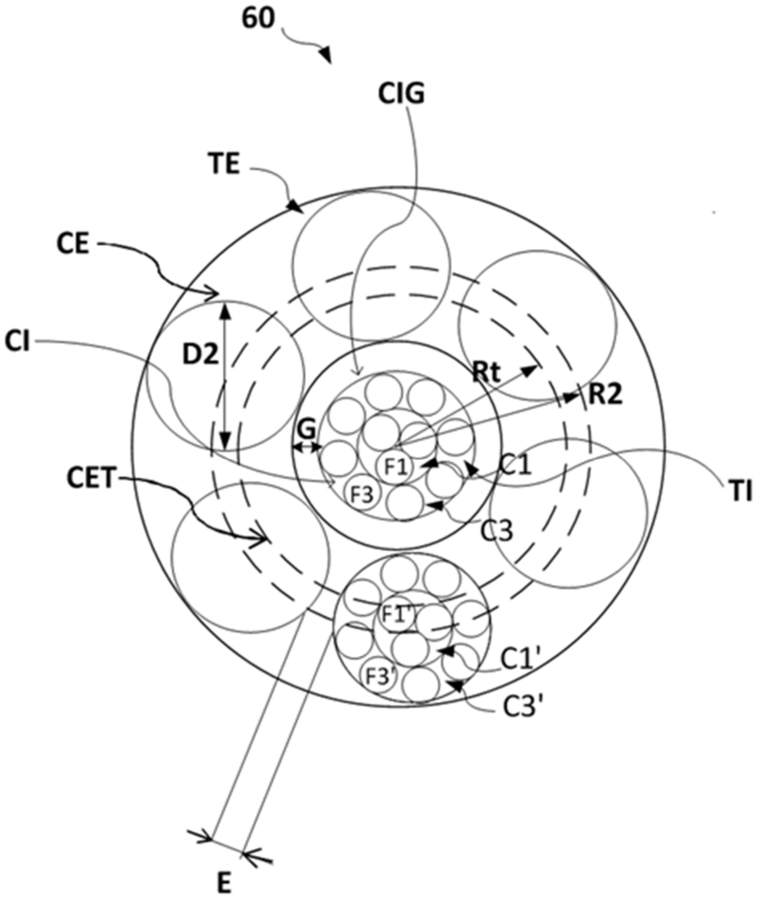


Fig.5

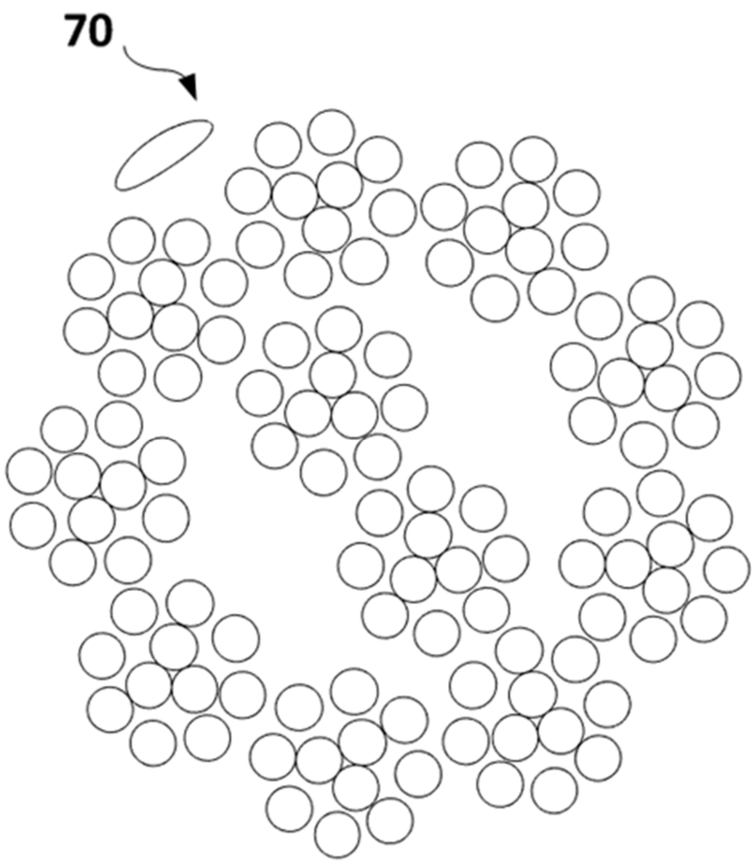


Fig.6

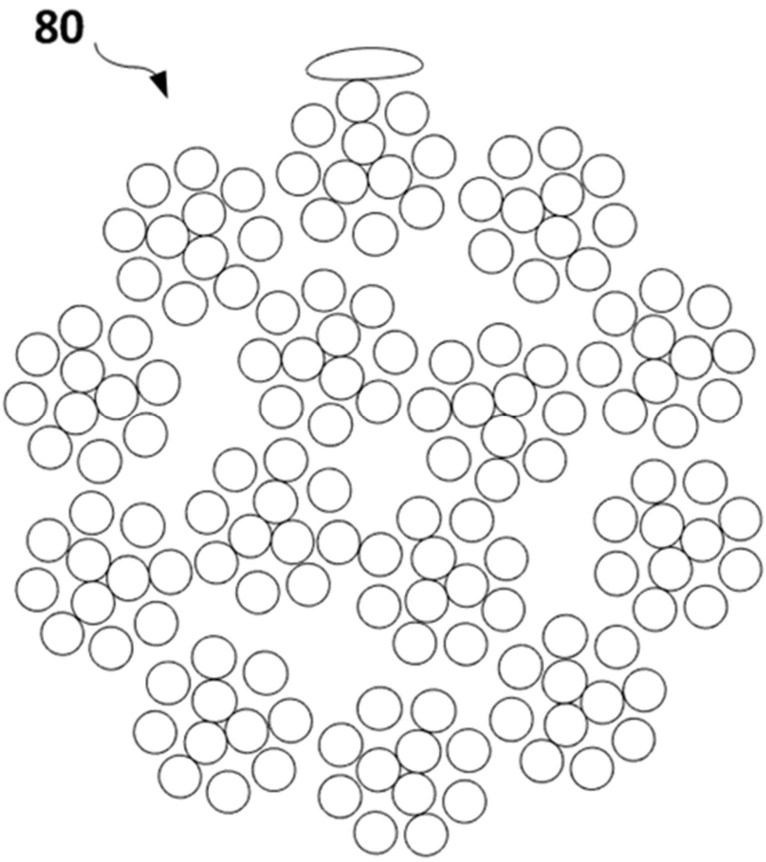


Fig.7

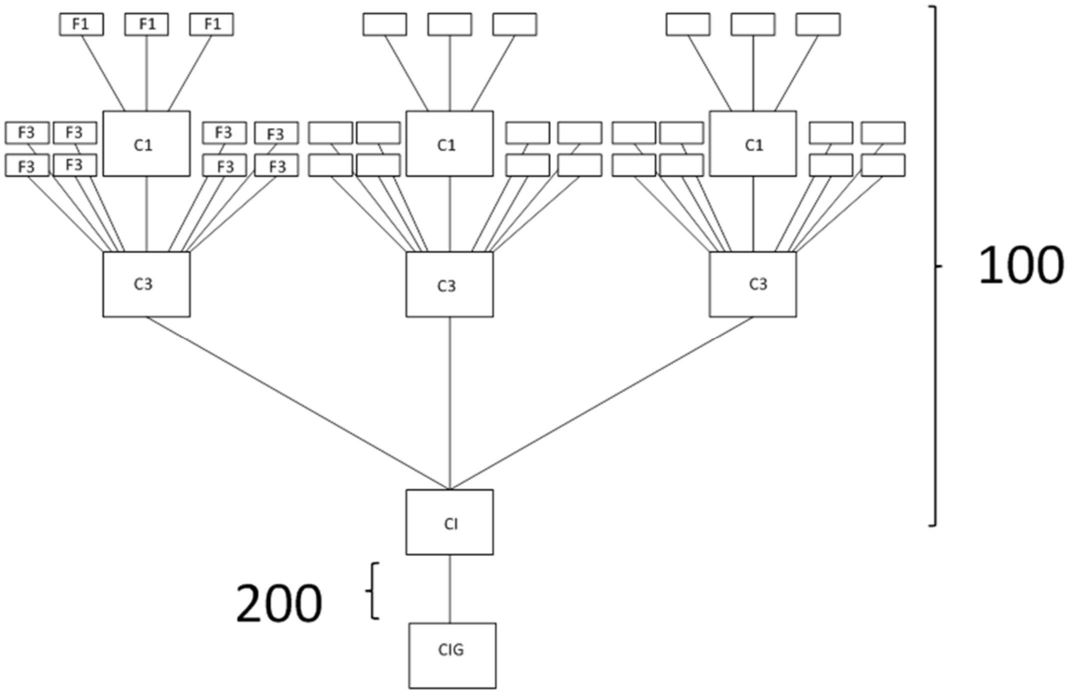


Fig.8

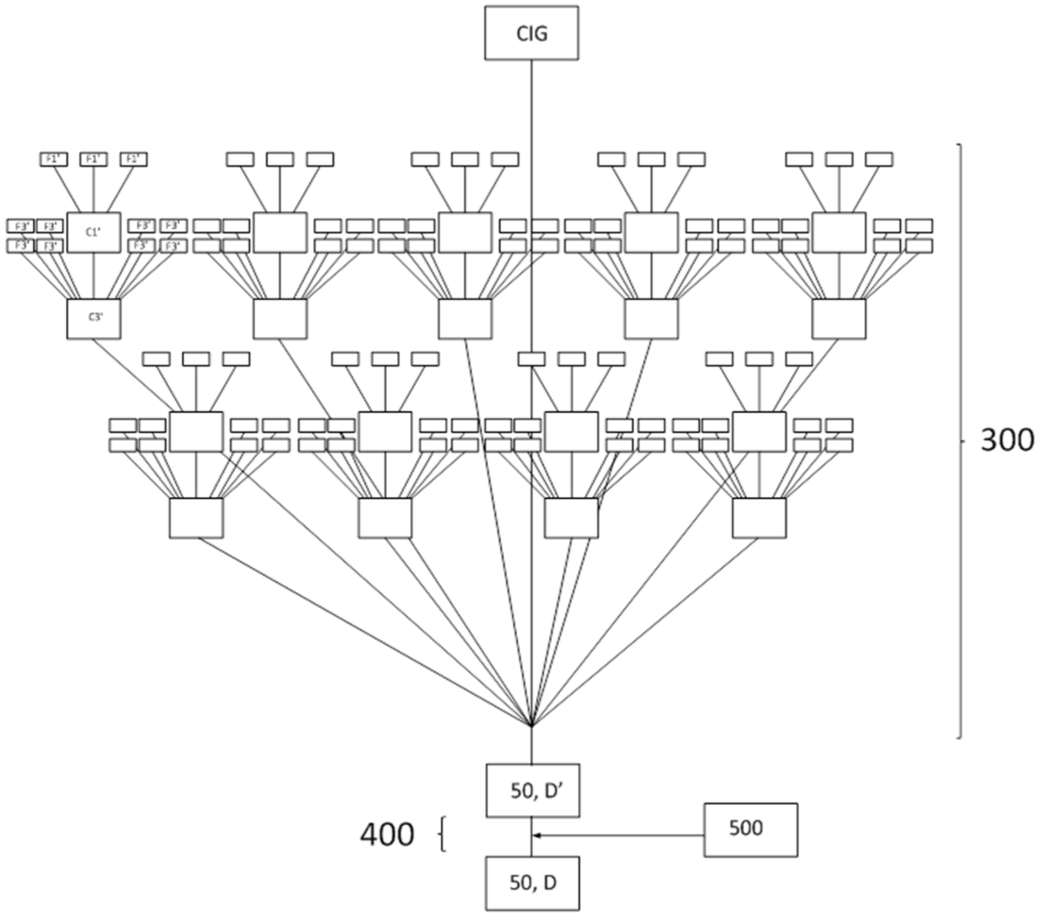


Fig.9

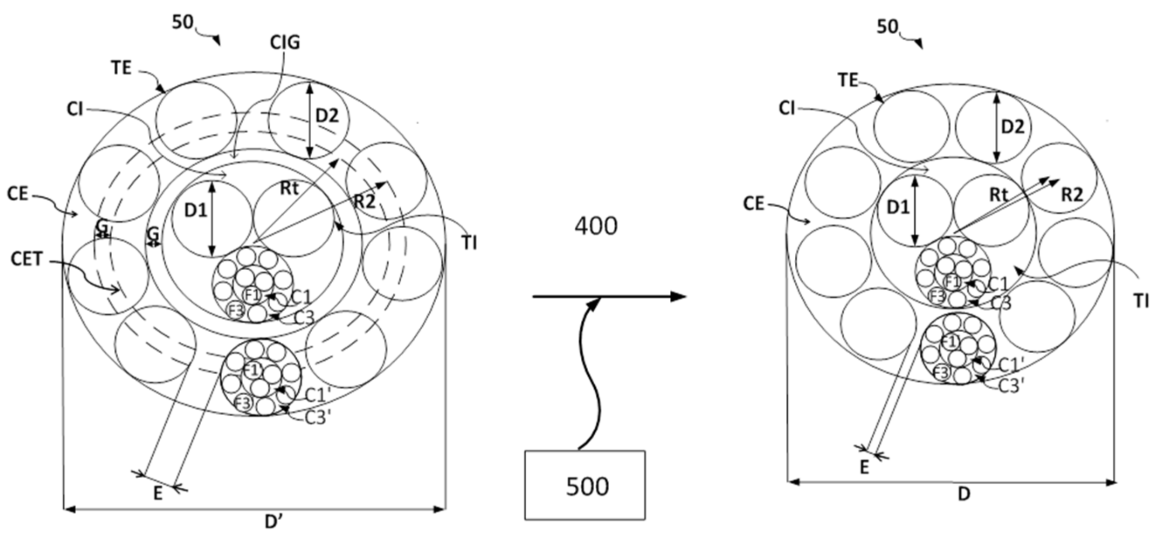
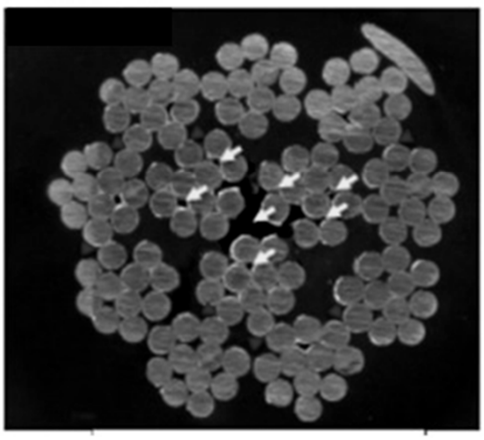

50
CIG
TE
CI
D2
CE
D1
Rt
R2
G
G
CET
TI
F1
C1
F3
C3
F1
C1'
F3
C3'
E
D'
400
500
50
TE
CI
D2
CE
D1
Rt
R2
F1
C1
F3
C3
TI
F1
C1'
F3
C3'
E
D

Fig.10

T1



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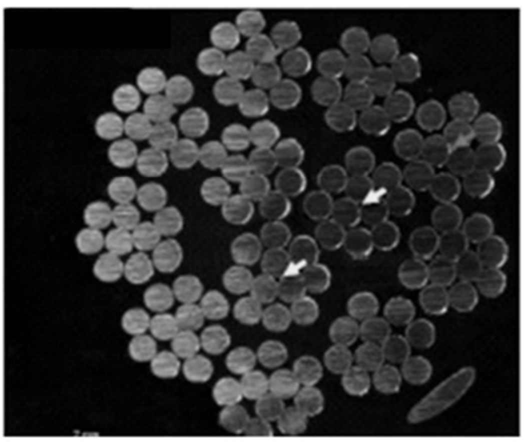

Fig.11