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(54) Title : TIRE BEAD FOR HEAVY CIVIL ENGINEERING VEHICLE

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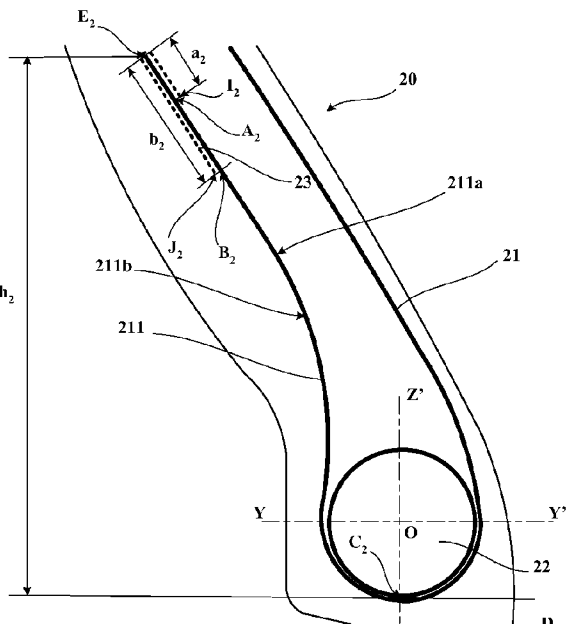

FIGURE 2

(57) Abstract : The invention relates to improving the endurance of the beads of a radial tire for a heavy civil engineering vehicle, by blocking the cracks that are initiated in the end turn-up area of the carcass reinforcement and that propagate in the adjacent polymer materials, bringing about the deterioration of the bead in the long term. According to the invention, an edging element (23), consisting of at least two edging layers made of textile material reinforcing elements, is in continuous contact with the turn-up (211) of the carcass reinforcement between a first point of contact (A2) on the axially inner turn-up surface (211a) of the carcass reinforcement, corresponding to a first end (I_2) of the edging element, and a last point of contact (B_2) on the axially outer turn-up surface (211b) of the carcass reinforcement.

(57) Abrégé : L'invention concerne l'amélioration de l'endurance des bourrelets d'un pneumatique radial pour

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véhicule lourd de type génie civil, en bloquant les fissures qui sont initiées dans la zone d'extrémité de retournement d'armature de carcasse et se propagent dans les matériaux polymériques environnants, entraînant dans la durée la dégradation du bourrelet Selon l'invention, un élément de bordage (23), constitué d'au moins deux couches de bordage constituées d'éléments de renforcement en matériau textile, est en contact continu avec le retournement d'armature de carcasse (211) entre un premier point de contact (A2) sur la face axialement intérieure (211a) de retournement d'armature de carcasse, correspondant à une première extrémité (I_2) de l'élément de bordage, et un dernier point de contact (B_2) sur la face axialement extérieure (211b) de retournement d'armature de carcasse.

TYRE BEAD FOR HEAVY CIVIL ENGINEERING VEHICLE

[0001] The present invention relates to a radial tyre designed to be fitted to a heavy vehicle of the civil engineering type.

[0002] Although not limited to this type of application, the invention will be more particularly described with reference to a radial tyre designed to be fitted to a dumper, a vehicle for transporting materials extracted from quarries or from opencast mines. The nominal diameter of the rim of such a tyre, within the meaning of the European Tyre and Rim Technical Organisation or ETRTO standard, is equal to the minimum at 25''.

[0003] In the following, the following designations are used:

- "Mid-plane": a plane containing the rotation axis of the tyre.
- "Equatorial plane": the plane passing through the middle of the tread surface of the tyre and perpendicular to the rotation axis of the tyre.
- "Radial direction": a direction perpendicular to the rotation axis of the tyre.
- "Axial direction": a direction parallel to the rotation axis of the tyre.
- "Circumferential direction": a direction perpendicular to a mid-plane.
- "Radial distance": a distance measured perpendicularly to the rotation axis of the tyre and from the rotation axis of the tyre.
- "Axial distance": a distance measured parallel to the rotation axis of the tyre and from the equatorial plane.
- "Radially": in a radial direction.
- "Axially": in an axial direction.
- "Radially inner, respectively radially outer": of which the radial distance is lesser, respectively greater.
- "Axially inner, respectively axially outer": of which the axial distance is lesser, respectively greater.

[0004] A tyre comprises a tread designed to come into contact with the ground, two sidewalls extending radially inwards from the ends of the tread, and two beads extending the sidewalls radially inwards and providing the mechanical connection between the tyre and the rim on which it is mounted.

[0005] A radial tyre comprises more particularly a reinforcement element, comprising a crown reinforcement, radially inside the tread, and a carcass reinforcement, radially inside the crown reinforcement.

[0006] The carcass reinforcement of a radial tyre for a heavy vehicle of the civil engineering type usually comprises at least one layer of carcass reinforcement consisting of metal reinforcement elements coated with a coating polymer material. The metal reinforcement elements of the carcass reinforcement layer are substantially parallel with one another and have a substantially radial direction, that is to say that they make, with the circumferential direction, an angle of between 85° and 95°.

[0007] The carcass reinforcement layer comprises a main carcass reinforcement portion, connecting the two beads together and winding in each bead, from the inside to the outside of the tyre, around a bead wire core, in order to form a carcass reinforcement upturn extending radially outwards to a carcass reinforcement upturn end and comprising two respectively axially inner and axially outer carcass reinforcement upturn faces.

[0008] The bead wire core usually consists of a circumferential reinforcement element most frequently made of metal surrounded by at least one, nonexhaustively polymer or textile, material. The winding of the carcass reinforcement layer around the bead wire core, from the inside to the outside of the tyre, and forming a carcass reinforcement upturn extending radially outwards, anchors the carcass reinforcement layer to the bead wire core of the bead.

[0009] The radial positioning of the carcass reinforcement upturn end is characterized by the carcass reinforcement upturn height which is the radial distance between the carcass reinforcement upturn end and the radially innermost point of the bead wire core. The carcass reinforcement upturn height determines the anchoring of the carcass reinforcement upturn in the polymer blends in contact respectively with the axially inner and axially outer carcass reinforcement upturn faces. The carcass reinforcement upturn height may be defined with the aid of a ratio relative to the radial distance between the radially outermost point of the tread and the radially innermost point of the bead.

[0010] "Axially inner carcass reinforcement upturn face" means the carcass reinforcement upturn face of which the external normal at any point of the said face has an axial component directed towards the inside of the tyre. "Axially outer carcass reinforcement upturn face" means the carcass reinforcement upturn face of which the outer normal at any point of the said face has an axial component directed towards the outside of the tyre.

[0011] The axially inner carcass reinforcement upturn face is in contact with a filling element radially extending the bead wire core outwards. The filling element has, in any mid-plane, a substantially triangular section and consists of at least one polymer filling material. The filling element may consist of a stack in the radial direction of at least two polymer filling materials in contact along a contact surface cutting any mid-plane along a meridian line. The filling element axially separates the main portion of carcass reinforcement and the carcass reinforcement upturn.

[0012] The axially outer carcass reinforcement upturn face is at least partly in contact with a stuffing element consisting of a polymer stuffing material. The stuffing element is axially inside the sidewall and a protective element radially extending the sidewall inwards, the sidewall and the protective element respectively consisting of a sidewall polymer blend and at least one protective polymer blend.

[0013] A polymer material, after curing, is characterized mechanically by characteristics of tensile stress-deformation determined by tension tests. These tension tests are carried out by those skilled in the art on a test specimen, according to a known method, for example according to international standard ISO 37, and in normal temperature conditions (23 + or – 2°C) and hygrometry conditions (50 + or -5% relative humidity), defined by international standard ISO 471. The modulus of elasticity at 10% elongation of a polymer blend, expressed in mega pascals (MPa), refers to the tensile stress measured for a 10% elongation of the test specimen.

[0014] A polymer material, after curing, is also characterized mechanically by its hardness. Hardness is notably defined by the Shore A hardness determined according to the standard ASTM D 2240-86.

[0015] When the vehicle is running, the tyre, mounted on its rim, inflated and squashed under the weight of the vehicle, is subjected to flexing cycles, in particular at its beads and its sidewalls.

[0016] The flexing cycles cause variations of curvature combined with variations of tension of the metal reinforcement elements of the main carcass reinforcement portion and of the carcass reinforcement upturn.

[0017] For a tyre with a carcass reinforcement upturn known as high, that is to say for which the carcass reinforcement height is at least equal to 0.3 times the radial distance between the radially outermost point of the tread and the radially innermost point of the bead, the flexing cycles in the sidewall cause the breakage of the metal reinforcement elements of the carcass reinforcement upturn portion situated in the flexing zone of the sidewall, capable of causing a deterioration of the tyre over time requiring its replacement.

[0018] For a tyre with a carcass reinforcement upturn known as low, that is to say for which the carcass reinforcement height is at most equal to 0.3 times the radial distance between the radially outermost point of the tread and the radially innermost point of the bead, the flexing cycles in the bead cause cracking of the polymer blends situated in the vicinity of the carcass reinforcement upturn end in a zone of high mechanical flexing and shearing stresses, capable of causing a deterioration of the tyre over time requiring its replacement. This cracking phenomenon at the end of the carcass reinforcement upturn also exists, but to a lesser degree, in the case of a high carcass reinforcement upturn.

[0019] In the case of a tyre with a high carcass reinforcement upturn, in order to prevent the problem of breakage of the metal reinforcement elements of the carcass reinforcement upturn portion, situated in the zone of flexing of the sidewall, those skilled in the art have proposed to reduce the height of the carcass reinforcement upturn in order to achieve a low carcass reinforcement upturn which is nevertheless sensitive to the cracking of the polymer blends, situated in the vicinity of the carcass reinforcement upturn end.

[0020] In the case of a tyre with a low carcass reinforcement upturn, documents FR 2901178, GB 2276357 and EP 0736400 describe solutions for solving the problem of cracking of the polymer blends, situated in the vicinity of the carcass reinforcement upturn end, consisting in coating the carcass reinforcement upturn end with a polymer material absorbing the deformations of the polymer blends that are present in this zone.

[0021] The inventors have set themselves the objective of improving the endurance of the beads of a radial tyre for a heavy vehicle of the civil engineering type by blocking the cracks that are initiated in the carcass reinforcement upturn end zone and are propagated in the surrounding polymer materials, causing the deterioration of the bead over time.

[0022] In accordance with the present invention, there is provided a tyre for a heavy vehicle of the civil engineering type including a tread, two sidewalls extending radially inwards from ends of the tread, two beads extending the sidewalls radially inwards and each including a bead wire core, a carcass reinforcement extending between the beads and including at least one carcass reinforcement layer consisting of metal reinforcement elements wound in each bead, from the inside to the outside of the tyre, around the bead wire core, in order to form a carcass reinforcement upturn extending radially outwards to a carcass reinforcement upturn end, the carcass reinforcement upturn including two respectively axially inner and axially outer faces of carcass reinforcement upturn, characterized in that a binding element, consisting of two superposed binding layers consisting of reinforcement elements made of textile material, is folding in continuous contact around the end of the carcass reinforcement upturn between a first point of contact on the axially inner face of the carcass reinforcement upturn, corresponding to a first end of the binding element, and a last point of contact on the axially outer face of the carcass reinforcement upturn, and in that the reinforcement elements of one said binding layer, are substantially parallel

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with one another, form a non-zero angle relative to the radial direction, and are crossed relative to the reinforcement elements of the other said binding layer.

[0023] Deleted

[0024] The binding element, consisting of at least two binding layers consisting of reinforcement elements made of textile material, reduces the speed of propagation of the cracks initiated in the polymer materials in contact with the carcass reinforcement upturn end zone. The initiation of the cracks in the polymer materials in contact with the metal reinforcement elements results from initial defects of adhesion between the ends of the metal reinforcement elements and the polymer blends in contact. The propagation of the cracks depends on the stresses in the polymer materials that are present in the carcass reinforcement upturn end zone. The binding element, consisting of at least two binding layers consisting of reinforcement elements made of textile material, will on the one hand reduce the stresses and deformations in the coating blend at the end of the carcass reinforcement upturn, and on the other hand block the propagation of the cracks in the polymer materials situated on either side of the carcass reinforcement upturn. The presence of at least two superposed binding layers constitutes a set of successive barriers to the propagation of the cracks.

[0025] Moreover, a continuous contact with the carcass reinforcement upturn between a first point of contact on the axially inner carcass reinforcement upturn face, corresponding to a first end of the binding element, and a last point of contact on the axially outer carcass reinforcement upturn face makes it possible to ensure the effect of slowing the cracking both on the axially inner face and axially outer face portions of the carcass reinforcement upturn.

[0026] It is also advantageous that the distance between the first point of contact on the axially inner face of carcass reinforcement upturn, corresponding to a first end of the binding element, and the end of carcass reinforcement upturn is at least equal to 5 times the diameter of a reinforcement element of the carcass reinforcement layer. This minimum contact distance ensures adhesion between the binding element and the axially inner carcass reinforcement upturn face. Below this minimum contact distance, there is a risk of the binding element coming unstuck, by an elastic return effect, because of the closeness of the carcass reinforcement upturn end around which the binding element is folded.

[0027] It is also advantageous to have the distance between the first point of contact on the axially inner face of carcass reinforcement upturn, corresponding to a first end of the binding element, and the end of carcass reinforcement upturn at most equal to 10 times the diameter of a reinforcement element of the carcass reinforcement layer. This maximum contact distance ensures that the portion of axially inner carcass reinforcement upturn face sensitive to cracking is covered. Beyond this maximum contact distance, the risk of cracking being less, the binding element becomes unnecessary with respect to the cracking while causing an additional cost of polymer material.

[0028] One advantageous embodiment of the invention is to have the last point of contact on the axially outer face of carcass reinforcement upturn corresponding to a second end of the binding element. This feature means that the second end of the element is necessarily in contact with the axially outer carcass reinforcement upturn face, the said face being, by convention, between the radially innermost point of the carcass reinforcement layer, radially inside the bead wire core, and the carcass reinforcement upturn end. In these conditions, the binding element is not engaged beneath the bead wire core.

[0029] It is also advantageous to have the distance between the last point of contact on the axially outer face of carcass reinforcement upturn, corresponding to the second end of the binding element, and the end of carcass reinforcement upturn is at least equal to 10 times the diameter of a reinforcement element of the carcass reinforcement layer. As for the contact of the binding element with the axially inner carcass reinforcement upturn face, this minimum contact distance ensures adhesion between the binding element and the axially outer carcass reinforcement upturn face. Below this minimum contact distance, there is a risk of the binding element coming unstuck, through an effect of elastic return, because of the closeness of the carcass reinforcement upturn end around which the binding element is folded.

[0030] It is also advantageous to have the distance between the last point of contact on the axially outer face of carcass reinforcement upturn, corresponding to the second end of the binding element, and the end of carcass reinforcement upturn at most equal to 20 times the diameter of a reinforcement element of the carcass reinforcement layer. This maximum contact distance ensures that the portion of axially outer carcass reinforcement upturn face sensitive to cracking is covered. Beyond this maximum contact distance, the binding element becomes unnecessary with respect to the cracking while causing an additional cost of polymer material.

[0031] One advantageous embodiment is to have the thickness of the binding element at least equal to 0.2 times the diameter of a reinforcement element of the carcass reinforcement layer. This is the minimum thickness necessary for ensuring a robust binding, that is to say making it possible to prevent the ends of the metal reinforcement elements of the carcass reinforcement upturn from entering the binding element and consequently damaging it.

[0032] Another advantageous embodiment is to have the thickness of the binding element at most equal to 0.6 times the diameter of a reinforcement element of the carcass reinforcement layer. Above this thickness, the folding of the binding element around the carcass reinforcement upturn end is difficult to achieve and is likely to cause manufacturing defects that may lead to the deterioration of the tyre in use.

[0033] The two binding layers of which the reinforcement elements made of textile material are crossed from one binding layer to the other thus constitute a fabric of which the weft provides a triangulation effect limiting the deformations in the polymer blend for coating the substantially radial metal reinforcement elements of the carcass

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reinforcement upturn: which slows down the propagation of the cracks initiated on the carcass reinforcement upturn.

[0034] The angles of the reinforcement elements respectively of the two binding layers of the binding element are advantageously equal to one another, in absolute value, and at least equal to 45°, relative to the circumferential direction. The angles being equal makes it possible to simplify manufacture since the respective angles of the reinforcement elements of the binding layers are identical except for the sign. The inventors have shown that an angle of at least 45°, relative to the circumferential direction, makes it possible to provide an optimal triangulation at the carcass reinforcement upturn end.

[0035] The angles of the reinforcement elements respectively of the two binding layers of the binding element are also advantageously at most equal to 80°, relative to the circumferential direction. Beyond an angle of 80°, there is no further triangulation effect because the reinforcement elements of the binding layers are then substantially parallel to the reinforcement elements of the carcass reinforcement upturn of which the angle relative to the circumferential direction is between 85° and 95°.

[0036] It is advantageous to have the reinforcement elements of the two binding layers of the binding element made of material of the aliphatic polyamide type, because this type of material ensures a slight flexing rigidity of the binding element allowing the binding element to fold around the carcass reinforcement upturn end and ensures a good resistance to compression of the reinforcement elements.

[0037] A preferred embodiment is to have the radial distance between the end of carcass reinforcement upturn and the radially innermost point of the bead wire core at most equal to 0.3 times the radial distance between the radially outermost point of the tread of the tyre and the radially innermost point of the bead of the tyre. This is the characteristic of a carcass reinforcement upturn known to be low, for which cracking at the end of the carcass reinforcement upturn is particularly sensitive and for which the binding element provides a significant advantage.

[0038] The features of the invention will be better understood with the aid of the description of the appended figures 1 to 3:

- Figure 1 shows a view in section in a mid-plane of the bead of a tyre for a heavy vehicle of the civil engineering type of the prior art.

- Figure 2 shows a view in section in a mid-plane of the bead of a tyre for a heavy vehicle of the civil engineering type, according to a first embodiment of the invention.

- Figure 3 shows a view in section in a mid-plane of the bead of a tyre for a heavy vehicle of the civil engineering type, according to a second embodiment of the invention.

[0039] Figures 1 to 3 are not shown to scale in order to make understanding easier.

[0040] Figure 1 shows a tyre bead 10 for a heavy vehicle of the civil engineering type of the prior art, comprising a carcass reinforcement comprising at least one carcass reinforcement layer 11 consisting of metal reinforcement elements winding, from the inside to the outside of the tyre, around a bead wire core 12, in order to form a carcass reinforcement upturn 111 extending radially outwards to a carcass reinforcement upturn end E_1, the carcass reinforcement upturn comprising two carcass reinforcement upturn faces respectively an axially inner face 111a and an axially outer face 111b.

[0041] Figure 2, showing a first embodiment of the invention, shows a tyre bead 20 for a heavy vehicle of the civil engineering type, comprising a carcass reinforcement comprising at least one carcass reinforcement layer 21 consisting of metal reinforcement elements winding, from the inside to the outside of the tyre, around a bead wire core 22, in order to form a carcass reinforcement upturn 211 extending radially outwards to a carcass reinforcement upturn end E_2, the carcass reinforcement upturn comprising two carcass reinforcement upturn faces, respectively an axially inner face 211a and an axially outer face 211b.

[0042] A binding element 23, consisting of at least one binding layer consisting of reinforcement elements made of textile material, is in continuous contact with the carcass reinforcement upturn 211, between a first point of contact A_2 on the axially inner carcass reinforcement upturn face 211a, corresponding to a first end I_2 of the binding element, and a last point of contact B_2 on the axially outer carcass reinforcement upturn face 211b, corresponding to a second end J_2 of the binding element.

[0043] The distances a_2 and b_2 are the distances measured respectively between the first point of contact A_2 on the axially inner face 211a of carcass reinforcement upturn 211 and the carcass reinforcement upturn end E_2, and between the last point of contact B_2 on the axially outer face 211b of carcass reinforcement upturn 211 and the carcass reinforcement upturn end E_2.

[0044] The distance h_2 is the distance measured parallel to the radial direction ZZ' between the end E_2 of carcass reinforcement upturn 211 and the radially innermost point C_2 of the bead wire core 22. This distance may be expressed as a ratio of the radial distance between the radially outermost point of the tyre tread, not shown, and the radially innermost point D_2 of the tyre bead 20.

[0045] Figure 3, showing a second embodiment of the invention, shows a tyre bead 30 for a heavy vehicle of the civil engineering type, comprising a carcass reinforcement comprising at least one carcass reinforcement layer 31 consisting of metal reinforcement elements winding, from the inside to the outside of the tyre, around a bead wire core 32, in order to form a carcass reinforcement upturn 311 extending radially outwards to a carcass reinforcement upturn end E_3, the carcass reinforcement upturn comprising two carcass reinforcement upturn faces, respectively an axially inner face 311a and an axially outer face 311b.

[0046] A binding element 33, consisting of at least two binding layer consisting of reinforcement elements made of textile material, is in continuous contact with the carcass reinforcement upturn 311, between a first point of contact A_3 on the axially inner carcass reinforcement upturn face 311a, corresponding to a first end I_3 of the binding element, and a last point of contact B_3 on the axially outer carcass reinforcement upturn face 311b, but not corresponding to a second end J_3 of the binding element. This embodiment provides an improvement with respect to the risk of a lack of cohesion between the blend for coating the axially outer face of the carcass reinforcement upturn and the polymer blend in contact. In this embodiment, a portion of the binding element 33, axially inside the radial axis ZZ' passing through the centre of the bead wire core, is no longer in contact with the axially outer carcass reinforcement upturn face 311b: the binding element 33 is said to be engaged beneath the bead wire core 32.

[0047] The distance a_3 is the distance measured between the first point of contact A_3 on the axially inner face 311a carcass reinforcement upturn 311 and the end E_3.

[0048] The distance h_3 is the distance measured parallel to the radial direction ZZ' between the end E_3 of carcass reinforcement upturn 311 and the radially innermost point C_3 of the bead wire core 32. This distance can be expressed as a ratio of the radial distance between the radially outermost point of the tyre tread, not shown, and the radially innermost point D_3 of the tyre bead 30.

[0049] The invention has been studied more particularly in the case of a tyre of dimension 59/80R63 for a heavy vehicle of the dumper type. According to the ETRTO standard, the nominal conditions of use for such a tyre are an inflation pressure equal to 6 bar, a static load equal to 99 tonnes and a distance travelled in an hour of between 16 km and 32 km.

[0050] The 59/80R63 tyre has been designed according to the first embodiment as shown in Figure 2.

[0051] In the example studied, the distance a_2 between the first point of contact A_2 on the axially inner face 211a of carcass reinforcement upturn 211, corresponding to a first end I_2 of the binding element 23 and the carcass reinforcement upturn end E_2 is equal to 35 mm, namely approximately 8 times the diameter of a reinforcement element of the carcass reinforcement layer equal to 4.5 mm.

[0052] The distance b_2 between the last point of contact B_2 on the axially outer face 211b of carcass reinforcement upturn 211, corresponding to a second end J_2 of the binding element 23 and the carcass reinforcement upturn end E_2 is equal to 70 mm, namely approximately 16 times the diameter of a reinforcement element of the carcass reinforcement layer equal to 4.5 mm.

[0053] The binding element 23 consists of two binding layers with a thickness equal to 0.8 mm. The thickness e of the binding element 23 is equal to 2 times the thickness of a binding layer, namely 1.6 mm, which represents 0.35 times the diameter of a reinforcement element of the carcass reinforcement layer equal to 4.5 mm.

[0054] The respective angles of the reinforcement elements of the binding layers are equal to +80° and -80° relative to the circumferential direction.

[0055] The material constituting the reinforcement elements of the binding element is a nylon, that is to say a material of the aliphatic polyamide type.

[0056] Finally, the radial distance h_2 between the end E_2 of carcass reinforcement upturn 211 and the radially innermost point C_2 of the bead wire core 22 is equal to 270 mm, which represents a ratio of 0.22 relative to the radial distance between the radially outermost point of the tyre tread and the radially innermost point D_2 of the tyre bead 20, equal in the case studied to 1240 mm.

[0057] The computation simulations by finished elements, carried out on the study tyre of dimension 59/80R63, show a 40% reduction in the maximum shearing deformations in the coating blend of the carcass reinforcement upturn, between the metal reinforcement elements of the carcass reinforcement upturn, when changing from the reference tyre to the tyre according to the invention as shown in Figure 2.

[0058] The invention should not be interpreted as being limited to the example illustrated in Figure 2, but may be extended to other variant embodiments characterized, for example and in a non-exhaustive manner, a number of binding layers of the binding element greater than two, reinforcement elements of the binding layers of the binding element consisting of a material different from one layer to the other, etc.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Tyre for a heavy vehicle of the civil engineering type including a tread, two sidewalls extending radially inwards from ends of the tread, two beads extending the sidewalls radially inwards and each including a bead wire core, a carcass reinforcement extending between the beads and including at least one carcass reinforcement layer consisting of metal reinforcement elements wound in each bead, from the inside to the outside of the tyre, around the bead wire core, in order to form a carcass reinforcement upturn extending radially outwards to a carcass reinforcement upturn end, the carcass reinforcement upturn including two respectively axially inner and axially outer faces of carcass reinforcement upturn, characterized in that a binding element, consisting of two superposed binding layers consisting of reinforcement elements made of textile material, is folding in continuous contact around the end of the carcass reinforcement upturn between a first point of contact on the axially inner face of the carcass reinforcement upturn, corresponding to a first end of the binding element, and a last point of contact on the axially outer face of the carcass reinforcement upturn, and in that the reinforcement elements of one said binding layer, are substantially parallel with one another, form a non-zero angle relative to the radial direction, and are crossed relative to the reinforcement elements of the other said binding layer.

2. Tyre for a heavy vehicle of the civil engineering type according to Claim 1, characterized in that the distance between the first point of contact on the axially inner face of the carcass reinforcement upturn, corresponding to a first end of the binding element, and the end of carcass reinforcement upturn is at least equal to 5 times a diameter of a said reinforcement element of the carcass reinforcement layer.

3. Tyre for a heavy vehicle of the civil engineering type according to Claims 1 or 2, characterized in that the distance between the first point of contact on the axially inner face of the carcass reinforcement upturn, corresponding to a first end of the binding element, and the end of carcass reinforcement upturn is at most equal to 10 times the diameter of a said reinforcement element of the carcass reinforcement layer.

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4. Tyre for a heavy vehicle of the civil engineering type according to any one of Claims 1 to 3, characterized in that the last point of contact on the axially outer face of the carcass reinforcement upturn corresponds to a second end of the binding element.

5. Tyre for a heavy vehicle of the civil engineering type according to Claim 1, characterized in that the distance between the last point of contact on the axially outer face of the carcass reinforcement upturn, corresponding to a second end of the binding element, and the end of the carcass reinforcement upturn is at least equal to 10 times a diameter of a said reinforcement element of the carcass reinforcement layer.

6. Tyre for a heavy vehicle of the civil engineering type according to Claim 1, characterized in that the distance between the last point of contact on the axially outer face of the carcass reinforcement upturn, corresponding to a second end of the binding element, and the end of the carcass reinforcement upturn is at most equal to 20 times a diameter of a said reinforcement element of the carcass reinforcement layer.

7. Tyre for a heavy vehicle of the civil engineering type according to any one of Claims 1 to 6, characterized in that a thickness of the binding element is at least equal to 0.2 times a diameter of a said reinforcement element of the carcass reinforcement layer.

8. Tyre for a heavy vehicle of the civil engineering type according to any one of Claims 1 to 6, characterized in that a thickness of the binding element is at most equal to 0.6 times a diameter of a said reinforcement element of the carcass reinforcement layer.

9. Tyre for a heavy vehicle of the civil engineering type according to any one of claims 1 to 8, characterized in that the angles of the reinforcement elements respectively of the two superposed binding layers of the binding element are equal to one another, in absolute value, and at least equal to 45°, relative to the circumferential direction.

10. Tyre for a heavy vehicle of the civil engineering type according to Claim 9, characterized in that the angles of the reinforcement elements respectively of the two superposed binding layers of the binding element are at most equal to 80°, relative to the circumferential direction.

11. Tyre for a heavy vehicle of the civil engineering type according to any one of Claims 1 to 10, characterized in that the reinforcement elements of the two superposed binding layers of the binding element are made of material of the aliphatic polyamide type.

12. Tyre for a heavy vehicle of the civil engineering type according to any one of Claims 1 to 11, characterized in that the radial distance between the end of carcass reinforcement upturn and the radially innermost point of the bead wire core is at most equal to 0.3 times the radial distance between the radially outermost point of the tread of the tyre and the radially innermost point of the bead of the tyre.

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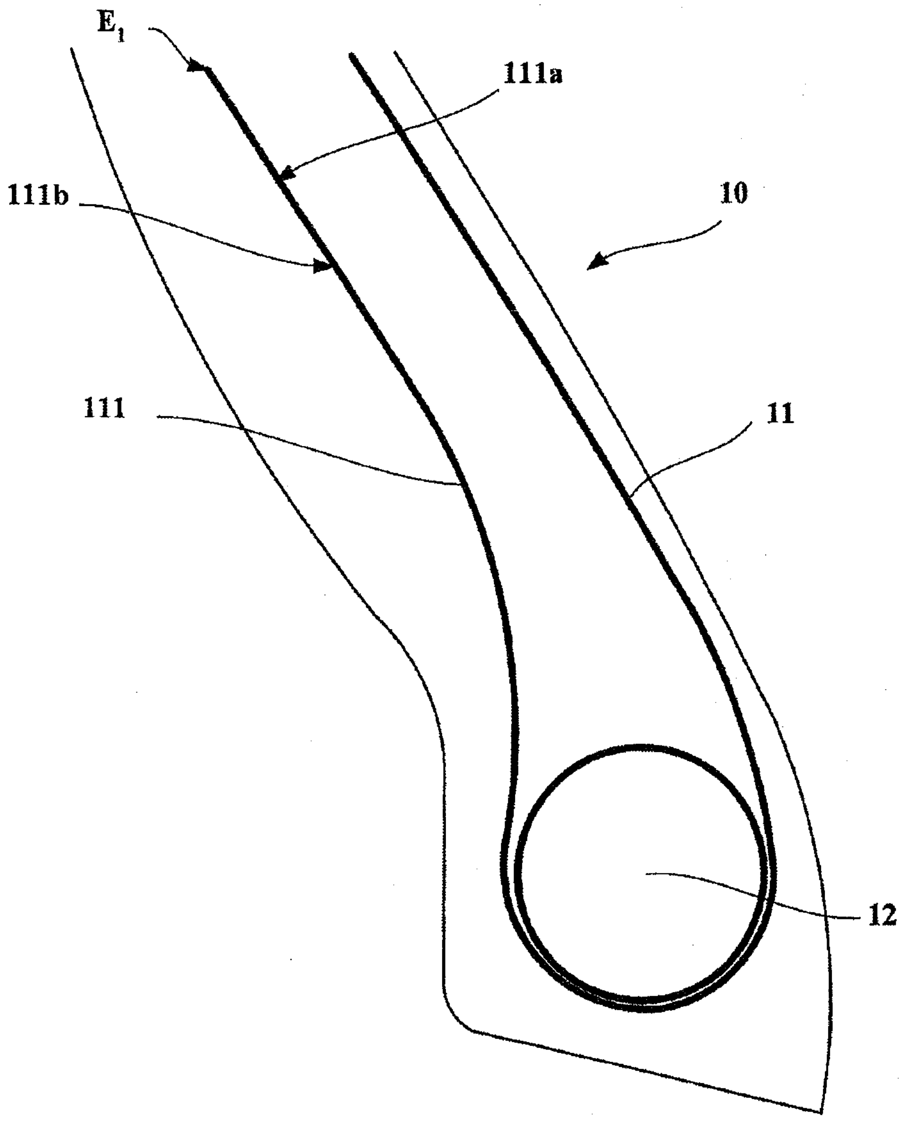

FIGURE 1

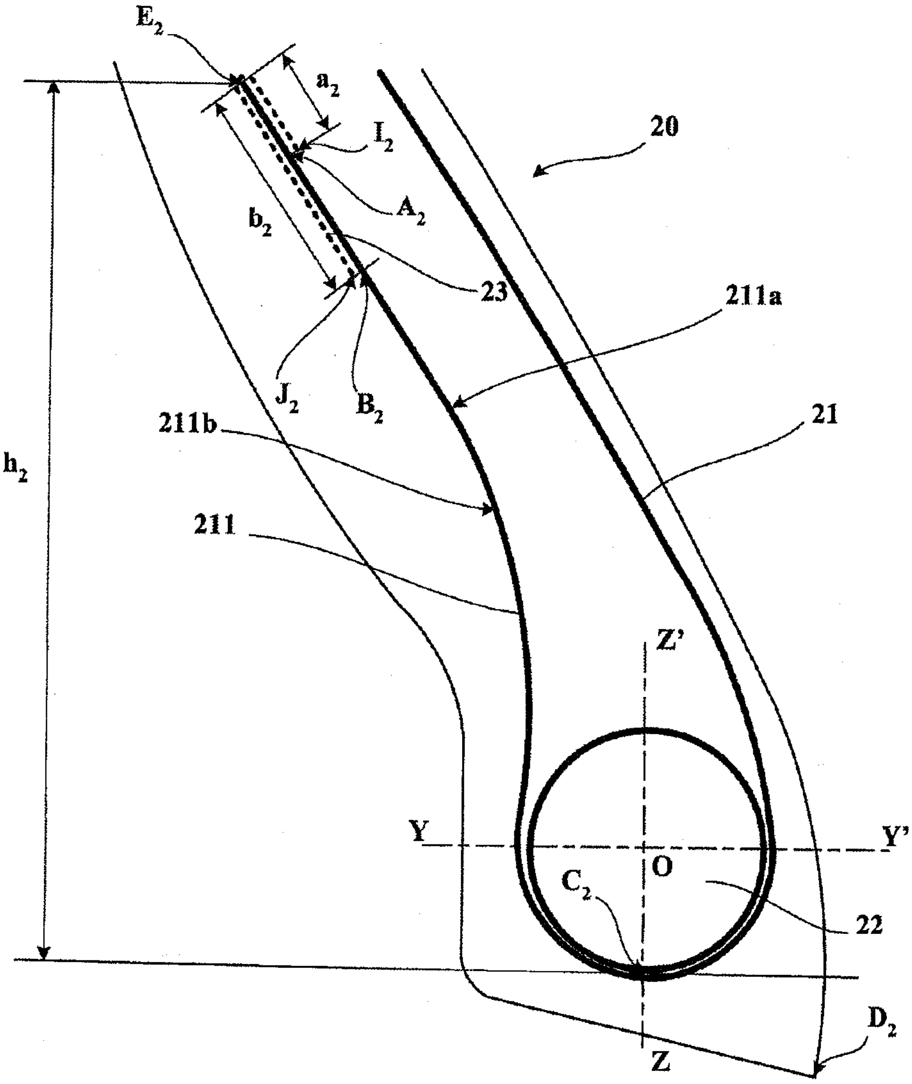

FIGURE 2

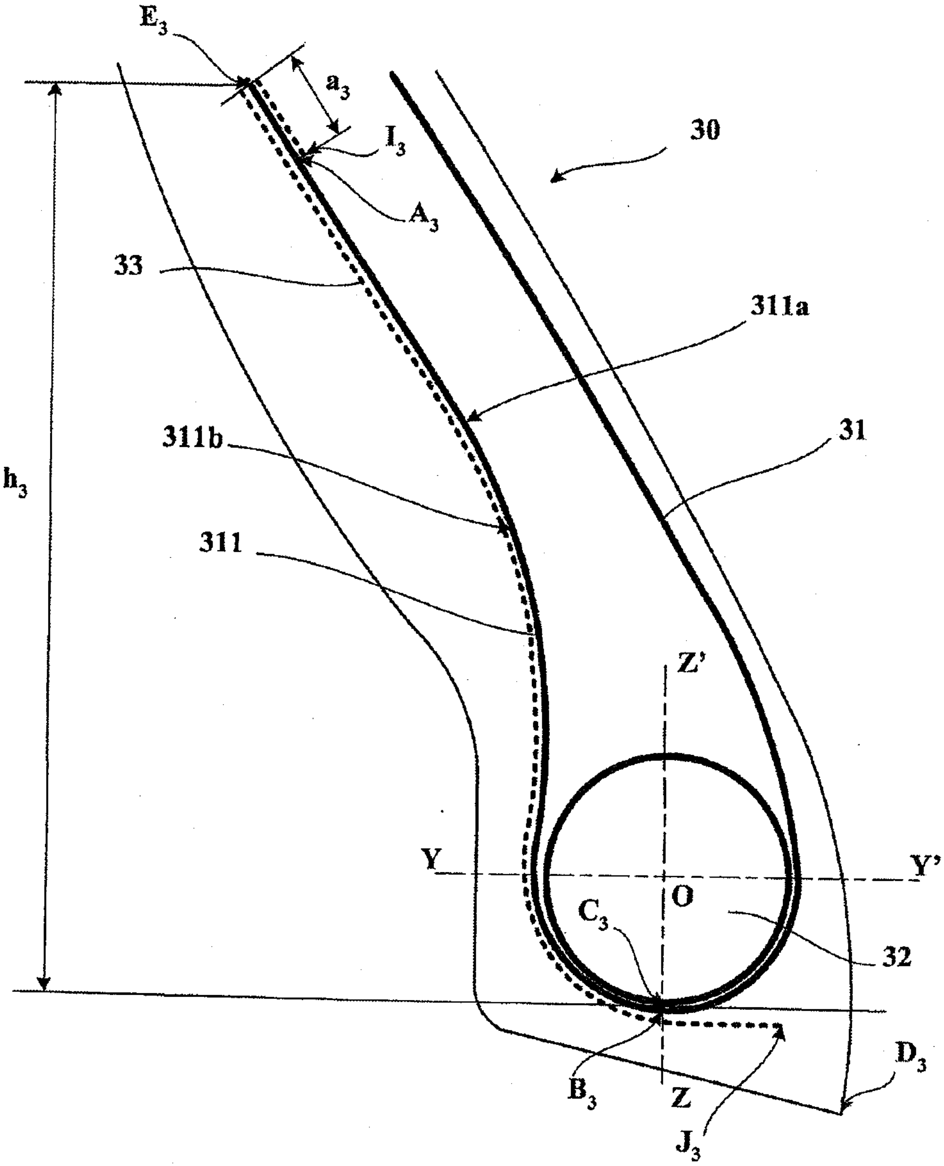

FIGURE 3