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(54) PNEUMATIC TYRE FOR VEHICLE WHEELS

(71) We, **INDUSTRIE PIRELLI S P A**, an Italian Company, of Centro Pirelli, Piazza D'Aosta No. 3, 20100, Milan, Italy, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to pneumatic tires for vehicle wheels, and more particularly, it concerns a new tire structure which permits important advantages over conventional tires as regards production and operation.

It is known that conventional tires comprise a carcass constituted by a plurality of cord plies, whose cords are subjected to tension in consequence of the inflation pressure.

It is also known that, during the building of a conventional tire, other components are added to the carcass plies, such as the bead cores about which the carcass plies are turned up, the tread band, the breaker positioned between the tread band and the carcass, and other reinforcements and fillers having particular functions; the assembly obtained being then shaped and finally cured in a mould.

It is evident that the manufacture of such a complicated structure cannot be mechanized beyond certain limits, so that, even nowadays, in the tyre industry manual work predominates over mechanical work.

It has been proposed to make tires devoid of carcass plies or breaker plies, and simply formed by pouring or injecting particular substances, such as synthetic resins or special rubbers, into appropriate moulds.

None of the attempts to carry out these proposals, however, has given positive results owing to the inability of such substances to confer to the tire the necessary mechanical characteristics.

Other attempts made to simplify, at least partially, the tire construction, consist of eliminating the carcass plies and maintaining only the breaker plies, the sidewalls of such tires being constituted by rubber only.

These attempts seem not to have given satisfactory results.

[Price 33p]

In practice, all these attempts have been based on the concept of exploiting the property of rubbery materials to withstand elastically compression stresses and bending stresses, and of utilizing the sidewalls of the tire, subjected to a very low inner pneumatic pressure, as elements co-operating in bearing the load. Therefore, the features of elasticity and of immediate reaction to deformations, which are typical of the compressed gas inside the tire, have been seriously compromised, so that the advantages afforded by pneumatic tires in which the elastic means is prevalently compressed gas (air) existing in their inside, have been given up.

The present invention aims at providing a pneumatic tire which, for its particular structure, can be built up, at least in part, by means of the conventional processes of pouring, injection moulding, or moulding on a male former, with all the consequent economic advantages, whilst permitting the use of materials already experimented within the tire industry and offering at the same time unexpected characteristics in respect of behaviour (such as very good comfort) and of uniformity of the produced article.

According to the present invention a pneumatic tire for vehicle wheels consists of a tread and two sidewalls comprising elastomeric material extending from the tread and terminating in beads which, in use, seat on a rigid wheel rim, in which tyre the tread is wider axially than the tire radially inwardly of the tread and is reinforced over substantially the whole of its width by an annular structure which is substantially inextensible when the tire is inflated in both its circumferential and lateral directions and in which the sidewalls each have a cross-sectional shape whose midline, over substantially its whole length between the tread reinforcement and the bead, is convex with respect to the interior of the tire, each said sidewall being such that it is constrained in compression between the tread reinforcement and the associated bead seat on the wheel rim on inflation of the tire and under service conditions. The references

to the inflated tyre herein refer to inflation pressures in the range at which the tyre is intended to be run when in use.

It will be appreciated that in the operation of this tyre the inflation pressure in the tyre is urging the sidewalls axially outwardly, reducing their curvature. The sidewall is so constructed in respect of, for example, its thickness, curvature and bending stiffness that it is too bulky and/or stiff to pass through the gap between the rigid wheel rim and the edge of the tread reinforcement and reverse its curvature. The effect of the inflation pressure is thus to compress the sidewall between the tread reinforcement and the wheel rim.

Preferably, in order to minimize heat build-up in the tire in use, each of the sidewalls comprises at least a zone having a bending stiffness, in a meridian plane, of a value lower than that of the bending stiffness of the remaining zones. Preferably such a zone is localized adjacent to the lateral edge of the tread or to the bead.

In the present specification, the expression "bending stiffness" of the sidewall at a given zone means the resistance of the sidewall in that zone to bending in a meridian plane. In the description, for the sake of simplicity, the ratios given refer to a specimen reproducing a cross-section of the tire in a meridian plane having a unitary thickness measured in the circumferential direction of the tire itself, and indicate the ratio between the bending moments necessary to impart the same variation in curvature in different parts of the specimen.

Preferably, the ratio between the bending stiffness at least at one of the low stiffness zones of each sidewall and the bending stiffness of the other zones of said sidewall does not exceed the value of 0.6 and is advantageously in the range 0.6 to 0.01.

The zone of lower bending stiffness (when this is only one for each sidewall) can be situated at the end of the sidewall near the edge of the inextensible annular structure.

However, in a particularly preferred embodiment, two zones of lower bending stiffness are provided in each sidewall, namely one in the proximity of the bead, in a radially outer position with respect to the bead retaining flange of the associated wheel rim, and the other, at the radially outer portion of the sidewall, in the proximity of the lateral edge of the inextensible annular reinforcement.

Preferably, the different values of bending stiffness are obtained by imparting different thicknesses to different parts of the sidewall. Thus the sidewall may wholly consist of a rubber having a comparatively high modulus, e.g. 40 Kg/cm², for sidewall rubber, and which has a higher modulus than the tread rubber, which may be, for example, 30 Kg/cm². Since the sidewalls of the tyre work under compression conventional bead cores

are not essential and the bead can be of the same material as the sidewall.

However, it is possible also to use various materials having different moduli of elasticity, for instance, a compound having a relatively low modulus at the zone of lower bending stiffness e.g. in the range 5 to 60 Kg/cm² and a compound having a relatively higher modulus, e.g. in the range 20 to 150 Kg/cm², or containing reinforcing fillers or other reinforcing materials such as fibres, oriented, if desired, in a preferred manner, at the zone of greater bending stiffness.

In the present specification, the expression "modulus of elasticity" of a compound means the modulus of linear elasticity or Young's modulus E, measured at the elongation produced by a load equal to 1/10 of the tensile strength of the compound, according to the known formula:

$$\frac{F}{s} = E \frac{\Delta l}{l}$$

where:

F is the load applied to the specimen

s is the cross-sectional area.

l is the initial length of the specimen

Δl is the extension caused by load F.

It is also preferred that the inextensible annular reinforcement, at least in proximity of its connection with each sidewall, has a transverse curvature whose concavity is directed towards the tire inside. Preferably the angle between the axis of rotation of the tire and the tangent to the profile of the annular reinforcement in the joining zone between the annular reinforcement and each of the two sidewalls is in the range 20° to 60°.

The tread pattern i.e. that part of the tyre coming into contact with the ground, may have a width the same as, or less than, the reinforced tread portion of the tyre.

The invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figures 1 and 2 are cross-sections of the tire, respectively not subjected to and subjected to the working inflation pressure. In both figures the contour of the tire sidewalls in the two conditions is indicated in dotted line to show the effects of the pneumatic pressure;

Figures 3 to 7 represent in scale some modified embodiments of the sidewalls of the tire shown in figure 1.

Figure 1 illustrates the cross section of a deflated tire, comprising a tread band 1. and annular reinforcing structure 2, two sidewalls 3 and 4 and two beads 5 and 6, which engage and firmly fit, in an already known way, in the shaped edges of a rim 7, having bead retaining flanges 8 and 9, and provided with a normal inflation valve 10.

The annular reinforcing structure 2 can be of various conventional types; preferably it comprises at least two layers of parallel textile or metallic cords, the cords in adjacent layers crossing each other, for instance, it can be of the type used in the tread ring described in U.K. Patent Specification No. 1,320,801. Although the structure 2 is radially flexible, especially at the central zone of the tread, it is however, substantially inextensible both in the transverse direction and in the circumferential direction when it is stressed by the inflation pressure; in order to constrain the sidewalls between its edges and the wheel rim so that the sidewalls are held in a compressed state. Thus the layers of cords may be stiffened at their lateral edges by means of folding back the cords, or by means of inextensible strips of cords arranged in the circumferential direction of the tyre.

The reinforcing structure may not necessarily be constituted by layers of cord fabrics, but also may be constituted, for instance, by homogeneous material in the form of foils, having a resistance to tension sufficient to withstand the action of the inflation pressure and of the stresses originated in service.

The annular reinforcing structure 2 extends axially for the whole upper part of the tire, including also the lateral zones of the tread, which are respectively connected with the sidewalls 3 and 4, where the annular structure 2 extends axially beyond the midlines of the sidewalls. The annular structure 2 and tread band 1 are curved in cross section so that between the sidewalls the tread arches outwardly.

As is clearly shown in figures 1 and 2, said lateral zones, together with the beads 5 and 6, define, in first approximation, the four vertices of an isosceles trapezium, whose longer side is adjacent to the tread, and coincides with the chord of the curvature of the section of the annular reinforcing structure 2, and whose sides are defined by the sidewalls of the tire itself, not considering, in first approximation, their typical curved shape, seen in section, which will be described hereinafter.

Since the annular reinforcing structure 2 is substantially inextensible, the distance between the two lateral edges of the annular reinforcement and the flanges 8 and 9 of the rim 7 can be considered as substantially invariable, so that the said lateral edges constitute fixed points, obviously in the absence of localized strong deforming stresses.

The tire illustrated by way of example in figure 1, which is intended to be fitted on a rim having flanges at an approximate distance of 90 mm from each other, has a maximum axial width of 150 mm, and the radial distance between the lateral edges of the structure 2 and the rim flanges is 30 mm. Therefore, the sidewalls 3 and 4 of the tire

converge (as indicated by the straight lines B—B in figure 2) in such a way that their prolongations cross with each other, forming an angle β which in the example is in the range 90° — 95° . In the same tire, the section height is 70 mm when inflated on its wheel rim and depends partially on the camber of the curvature of the inextensible structure 2 and of the tread 1.

In the preferred embodiment illustrated in figures 1 and 2, the annular reinforcement 2, at the zones of connection with the sidewalls 3 and 4, has a curvature whose concavity is directed towards the tire inside; the tangents to the profile of said structure in such zones of connection form with the horizontal axis XX, parallel to the axis of rotation of the tire, an angle α of 40° .

The sidewalls 3 and 4 have in cross section a particular curved shape, thickened at their centres more than in their radially inner and outer zones, and the respective section midlines 11 and 12 in the meridian plane show a considerable convexity directed towards the tire inside.

The section midline of each sidewall is a line lying in an equidistant position from the interior surface and exterior surface respectively of the sidewall. Thus, if in the cross section of the sidewall a series of circles are inscribed tangential to the interior surface and exterior surface, the line which joins the centres of the circles forms the section midline.

By proceeding from the radially outermost portion towards the radially innermost portion, the sidewall 4 (which is symmetrical to the corresponding sidewall 3) shows four typical zones, namely: a first zone 13, which connects the sidewall to the upper portion of the tire, comprising the tread band 1 and the annular reinforcement 2; a second zone 14 having a relatively small thickness; a third zone 15 having a thickness greater than that of zone 14; and a fourth zone 16 having a thickness comparable with that of zone 14. It can be therefore said that each sidewall comprises a thickened central portion and two portions, indicated with 14 and 16 which, having a thickness smaller than that of the thickened portion, have also a lower bending stiffness. Beyond these portions of relatively low thickness, there are respectively the bead, fitted on the rim, and the zone 13 leading to the edge of the annular reinforcement; also the bead, like the end of the annular reinforcement can be considered as a fixed point, since it is fitted on the rim, owing to the structural rigidity of the latter.

It will be noted that in the short length of sidewall in zone 13 the section midline becomes slightly concave to the tire interior but this part of the sidewall constitutes a comparatively massive triangular section piece of rubber which is anchored by the annular

reinforcement and is sufficiently stiff to resist any axially outward movement of the sidewall.

In the illustrated tire, each sidewall and bead is made entirely from the same material and the ratio between the thickness of the portion 15 and the smaller thickness of the portions 14 and 16 of the sidewall is equal to about 1.78. The moduli of elasticity of the two sections of the sidewall are equal to each other, the ratio between the two moments of inertia, being equal to 1.78³, is 5.6 and therefore the ratio between the bending stiffness of the portions 14 and 16 and the bending stiffness of the portion 15 is in this case equal to 0.18.

Only by way of non-limiting example, the sidewalls 3 and 4 and beads 5 and 6 of the tire illustrated in figures 1 and 2 can be constituted by a rubber compound having a modulus of elasticity of 40 Kg/cm², and the tread 1 by a compound having a modulus of elasticity of 30 Kg/cm².

The behaviour of the above described tire is as follows.

When air is admitted inside the tire (in the above described example the pressure is of the order of 1.5 to 3 atm) by means of the valve 10, the pressure of such inflation air normally acts on the inner walls of the sidewalls 3 and 4 of the tire. The effect of such pressure is that of pushing the sidewalls towards the tire outside, reducing in this way the curvature of the respective section midlines 11 and 12. Since—as said above—the bead and the edges of the annular reinforcing structure 2 behave as points whose distance is substantially invariable, each sidewall is constrained between these points and although it is subjected to the indicated pressure, becomes shortened in consequence of the reduction of the camber of its original curvature and is subjected to a compression in its whole section. The resistance or compressive and bending stiffness of the material is such that it does not allow said shortening to achieve the value defined by said distance between said points, so that the sidewalls do not invert the sense of their curvature. Consequently the sidewalls are subjected to compression; this state of stress is contrary to that existing in known conventional tires.

The shape taken by the tire after its inflation is shown in figure 2. As it can be seen from said figure, the curvature of the sidewalls has decreased, but maintains the same sense. It is moreover evident that any further movement of the sidewalls, to reduce their curvature, is resisted by the presence of the points at invariable distance, as indicated above, corresponding to the beads and to the lateral edges of the annular reinforcing structure, since the sidewall remains constrained between these points and said movement would result in a further shortening of

the sidewalls which are already stressed in compression and therefore resistant to further compression.

The advantages offered by the tire according to this invention are many. First of all, the sidewalls do not require the presence of tension-resistant reinforcing structures, and therefore can be obtained by means of a simple pouring or injection moulding process, or the like.

This results in economic advantages, since there is a possibility of a greater mechanization of production with respect to the present technique of construction of normal tires and also a greater uniformity of production.

Secondly, owing to the particular configuration of the tire according to the present invention, and in particular of that of its sidewalls, in the event of a puncture, with the consequent drop of pressure, the tire does not collapse completely, but its sidewalls act as pads between the reinforced thread and the rim flanges 8 and 9, supporting, even if at reduced speed and for a relatively short run, the load of the vehicle, without the risk of a complete destruction of the tire and with a better safety for the user.

Moreover, it has been surprisingly ascertained that the radial stiffness of the described tire is independent of its transverse stiffness.

It is well known that, when the inflation pressure in conventional tires is increased, both the radial stiffness and the transverse stiffness are increased; in other words, these two stiffnesses are correlated to each other and are both dependent on the value of the inflation pressure, so that, if it is wished to increase the transverse stiffness to obtain a better transverse stability of the tire, it is necessary to accept reduced comfort.

In the tires of this invention the stiffnesses of the various parts of the sidewall in the meridian plane can be obtained in several ways; in the tire shown in figures 1 and 2 they are obtained by virtue of particular profiles of the sidewalls, which show variations of thickness.

Obviously, the shapes illustrated in figures 1 and 2 are not the only possible ones; figures 3, 4 and 5 represent three alternative embodiments of sidewalls which can be adopted in the tire of figures 1 and 2. Figure 3 illustrates a sidewall, whose central zone 35 is substantially ovoidal and is connected to a bead and to an edge of the annular structure through the two zones 36 and 37 of smaller thickness.

The sidewall illustrated in figure 3 is also provided with a bead core 38, positioned in the bead 39, of a type analogous to that used in conventional tires. In this connection it is also to be noted that, on account of the working under compression of the sidewalls of the tire according to the invention, the

presence of circumferentially inextensible reinforcing elements in the bead is unnecessary, contrary to what happens in conventional tires.

5 Figure 4 shows a further embodiment of the sidewall, also suitable for the tire of figures 1 and 2, in which the central portion 40 has a substantially triangular shape and is connected to an edge of the annular reinforcing structure and to a bead through the zones of smaller thickness 41 and 42. In this embodiment, instead of using bead cores of known type, provision is made of a structure 43 of annular shape, formed by textile or metallic wires or cords disposed circumferentially side-by-side.

10 Figure 5 shows a further embodiment, in which the central portion 44 has a substantially elliptical shape and is connected to an edge of the annular structure and to a bead through the zones of smaller thickness 45 and 46.

20 Figure 6 shows a sidewall of the type of that of figure 1, constituted by two compounds having different moduli of elasticity. The compound of the zones 47 and 48 and that of the bead 49, has a modulus of elasticity of 60 Kg/cm², whilst the compound of the zones 50 and 57 has a modulus of elasticity of 20 Kg/cm².

30 Figure 7 shows a sidewall of the type of that of figure 1, constituted by several compounds; the compound constituting the zone 52 has a modulus of elasticity of 60 Kg/cm²; the compound of the zone 53, in order to increase its compression stiffness namely to avoid that the sidewall may shorten to such an extent as to remove its curvature, contains short fibers of a material having a modulus of elasticity higher than the rubber compound itself, e.g. glass fibres oriented in a preferred manner e.g. orientated to lie in meridian planes and along the length of the sidewall viewed in cross-section to best enhance the resistance to compression, or orientated in the circumferential direction of the tyre for ease of building up of the sidewall; the compound constituting the zone 55 has a modulus of elasticity of 15 Kg/cm², whilst the bead 56 is constituted by a compound having a modulus of elasticity of 80 Kg/cm².

55 In the embodiments of figures 6 and 7, described above, the differences of bending stiffness between the various zones of the sidewall are greater with respect to those of the sidewalls having an analogous profile and illustrated in figures 1 and 2, since in said embodiments the zones of smaller thickness, namely the zones 50 and 57 of figure 6 and the zone 55 of figure 7, are constituted by a compound having a modulus of elasticity lower than that of the compound forming the surrounding zones.

60 It is clear that, by appropriately selecting the moduli of the compound forming the

various parts of the sidewall, it is also possible to obtain the zones of the lower bending stiffness by the simple use of a compound having a low modulus of elasticity, without acting on the thicknesses.

70 It will be appreciated that the above described invention can be applied to any type of tire, having an integral or a removable tread, or having an integral or removable assembling rim.

WHAT WE CLAIM IS:—

1. A pneumatic tire for vehicle wheels consisting of a tread and two sidewalls comprising elastomeric material extending from the tread and terminating in beads which, in use, seat on a rigid wheel rim, in which tyre the tread is wider axially than the tire radially inwardly of the tread and is reinforced over substantially the whole of its width by an annular structure which is substantially inextensible when the tire is inflated in both its circumferential and lateral directions and in which the sidewalls each have a cross-sectional shape whose midline, over substantially its whole length between the tread reinforcement and the bead, is convex with respect to the interior of the tire, each said sidewall being such that it is constrained in compression between the tread reinforcement and the associated bead seat on the wheel rim on inflation of the tire and under service conditions.

2. A pneumatic tire according to claim 1 in which the annular structure reinforcing the tread extends axially outwardly to beyond the section midlines of the sidewalls.

3. A pneumatic tire according to claim 1 or 2 in which, in cross-section, the tread and annular reinforcing structure are arched outwardly between the sidewalls.

4. A pneumatic tire according to claim 1, 2 or 3 in which in cross-section the ends of the sidewalls adjacent to the edges of the annular reinforcing structure and to the beads, respectively, define the vertices of an isosceles trapezium, whose larger base is adjacent to the tread and whose sides are defined by the chords of the curvatures shown by the section midlines of the sidewalls which are wholly internal to the sides of the trapezium.

5. A pneumatic tire according to any one of the preceding claims in which each sidewall comprises at least one zone, localized adjacent to the lateral edge of the reinforced tread or to the bead, in which the bending stiffness is smaller than the stiffness of the remaining parts of the sidewall.

6. A pneumatic tire according to claim 5, in which the ratio between the bending stiffness at least at one of said low stiffness zones of each sidewall and the bending stiffness of the other parts of said sidewall does not exceed a value of 0.6.

7. A pneumatic tire according to claim 6,



presence of circumferentially inextensible reinforcing elements in the bead is unnecessary, contrary to what happens in conventional tires.

5 Figure 4 shows a further embodiment of the sidewall, also suitable for the tire of figures 1 and 2, in which the central portion 40 has a substantially triangular shape and is connected to an edge of the annular reinforcing structure and to a bead through the zones of smaller thickness 41 and 42. In this embodiment, instead of using bead cores of known type, provision is made of a structure 43 of annular shape, formed by textile or metallic wires or cords disposed circumferentially side-by-side.

10 Figure 5 shows a further embodiment, in which the central portion 44 has a substantially elliptical shape and is connected to an edge of the annular structure and to a bead through the zones of smaller thickness 45 and 46.

15 Figure 6 shows a sidewall of the type of that of figure 1, constituted by two compounds having different moduli of elasticity. The compound of the zones 47 and 48 and that of the bead 49, has a modulus of elasticity of 60 Kg/cm², whilst the compound of the zones 50 and 57 has a modulus of elasticity of 20 Kg/cm².

20 Figure 7 shows a sidewall of the type of that of figure 1, constituted by several compounds; the compound constituting the zone 52 has a modulus of elasticity of 60 Kg/cm²; the compound of the zone 53, in order to increase its compression stiffness namely to avoid that the sidewall may shorten to such an extent as to remove its curvature, contains short fibers of a material having a modulus of elasticity higher than the rubber compound itself, e.g. glass fibres oriented in a preferred manner e.g. orientated to lie in meridian planes and along the length of the sidewall viewed in cross-section to best enhance the resistance to compression, or orientated in the circumferential direction of the tyre for ease of building up of the sidewall; the compound constituting the zone 55 has a modulus of elasticity of 15 Kg/cm², whilst the bead 56 is constituted by a compound having a modulus of elasticity of 80 Kg/cm².

25 In the embodiments of figures 6 and 7, described above, the differences of bending stiffness between the various zones of the sidewall are greater with respect to those of the sidewalls having an analogous profile and illustrated in figures 1 and 2, since in said embodiments the zones of smaller thickness, namely the zones 50 and 57 of figure 6 and the zone 55 of figure 7, are constituted by a compound having a modulus of elasticity lower than that of the compound forming the surrounding zones.

30 It is clear that, by appropriately selecting the moduli of the compound forming the

various parts of the sidewall, it is also possible to obtain the zones of the lower bending stiffness by the simple use of a compound having a low modulus of elasticity, without acting on the thicknesses.

It will be appreciated that the above described invention can be applied to any type of tire, having an integral or a removable tread, or having an integral or removable assembling rim.

WHAT WE CLAIM IS:—

1. A pneumatic tire for vehicle wheels consisting of a tread and two sidewalls comprising elastomeric material extending from the tread and terminating in beads which, in use, seat on a rigid wheel rim, in which tyre the tread is wider axially than the tire radially inwardly of the tread and is reinforced over substantially the whole of its width by an annular structure which is substantially inextensible when the tire is inflated in both its circumferential and lateral directions and in which the sidewalls each have a cross-sectional shape whose midline, over substantially its whole length between the tread reinforcement and the bead, is convex with respect to the interior of the tire, each said sidewall being such that it is constrained in compression between the tread reinforcement and the associated bead seat on the wheel rim on inflation of the tire and under service conditions.

2. A pneumatic tire according to claim 1 in which the annular structure reinforcing the tread extends axially outwardly to beyond the section midlines of the sidewalls.

3. A pneumatic tire according to claim 1 or 2 in which, in cross-section, the tread and annular reinforcing structure are arched outwardly between the sidewalls.

4. A pneumatic tire according to claim 1, 2 or 3 in which in cross-section the ends of the sidewalls adjacent to the edges of the annular reinforcing structure and to the beads, respectively, define the vertices of an isosceles trapezium, whose larger base is adjacent to the tread and whose sides are defined by the chords of the curvatures shown by the section midlines of the sidewalls which are wholly internal to the sides of the trapezium.

5. A pneumatic tire according to any one of the preceding claims in which each sidewall comprises at least one zone, localized adjacent to the lateral edge of the reinforced tread or to the bead, in which the bending stiffness is smaller than the stiffness of the remaining parts of the sidewall.

6. A pneumatic tire according to claim 5, in which the ratio between the bending stiffness at least at one of said low stiffness zones of each sidewall and the bending stiffness of the other parts of said sidewall does not exceed a value of 0.6.

7. A pneumatic tire according to claim 6,



- in which said ratio is in the range 0.6 to 0.01.
8. A pneumatic tire according to any one of claims 5 to 7 in which two said zones of lower bending stiffness are provided in each sidewall, one in proximity to the bead, in a radially outer position in use with respect to the bead retaining flange of an associated wheel rim, and the other at the radially outer portion of the sidewall, in proximity to the lateral edge of said annular reinforcing structure.
9. A pneumatic tire according to any one of claims 5 to 8, in which the various values of bending stiffness of the sidewall zones are obtained by imparting different thicknesses to different parts of the sidewall.
10. A pneumatic tire according to any one of claims 5 to 9 in which various values of bending stiffness are obtained using materials having different moduli of elasticity.
11. A pneumatic tire according to claim 10 in which the zones of lower bending stiffness in the sidewalls are constituted by a compound having a modulus of elasticity, in the range 5 to 60 Kg/cm², whilst the zones of greater bending stiffness are constituted by a compound having a modulus of elasticity, in the range 20 to 150 Kg/cm².
12. A pneumatic tire according to any one of claims 1 to 11 in which each sidewall is made wholly of rubber which has a higher modulus than that of the tread rubber.
13. A pneumatic tire according to any one of claims 1 to 11 in which each sidewall and bead is constructed wholly of a rubber which is of higher modulus than the tread rubber.
14. A pneumatic tire according to claim 10, in which the zones of greater bending stiffness in the sidewalls are constituted by a compound incorporating short fibres of a material having a modulus of elasticity higher than that of the compound itself.
15. A pneumatic tire according to claim 14, in which said fibres are made of glass and are orientated in a preferred manner.
16. A pneumatic tire according to any one of claims 1 to 12, 14 and 15 in which the beads each contain an inextensible reinforcing core.
17. A pneumatic tire according to any one of the preceding claims, in which in the proximity of its joining with each sidewall, said annular reinforcing structure shows a transverse curvature having its concavity directed towards the tire inside.
18. A pneumatic tire according to claim 17, in which the angle between the axis of rotation of the tire and the tangent to the profile of the annular reinforcing structure in the joining zone between said annular reinforcing structure and each of the two sidewalls is in the range 20° to 60°.
19. A pneumatic tire according to any one of the preceding claims, in which said annular structure comprises at least two layers of parallel textile or metallic cords, the cords in adjacent layers crossing each other.
20. A pneumatic tire according to claim 19 in which the layers of cords are stiffened at their lateral edges by means of folding back the cords, or by means of inextensible strips of cords arranged in the circumferential direction of the tire.
21. A pneumatic tire substantially as described herein with reference to, and as illustrated in, the accompanying drawings.
- R. I. G. McKAY,
Agent for the Applicants.