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(54) PNEUMATIC TIRE FOR VEHICLE WHEEL

(71) We, INDUSTRIE PIRELLI SPA., an Italian Company of Centro Pirelli, Piazza Duca 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 to be obtained as regards manufacture, behaviour under load and ability of absorbing obstacles.

It is known, inter alia, that conventional pneumatic tires comprise a carcass constituted by a plurality of cord fabric plies, whose cords are subjected to tension in consequence of the inflation pressure. To these plies, during tire building, other components are added, 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 is then shaped and at last 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 tire industry manual work prevails over mechanical work.

Some proposals are known, which have been directed to producing 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 in order 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 also seem not to have given satisfactory results.

The present invention aims at providing a pneumatic tire which can be built up, at least in part, by means of the conventional processes of pouring, injection, or moulding on a male former, with all the consequent economic advantages, 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 elastic absorption of impact as the tire passes over obstacles.

According to the present invention there is provided a pneumatic tire for vehicle wheels having a tread reinforced by an annular structure substantially inextensible when the tyre is inflated in its transverse and circumferential directions and two sidewalls comprising elastomeric material extending from the lateral edges of the tread and terminating in beads able to fit firmly on the bead seats of a rigid wheel rim, in which each sidewall includes three portions, one near the tread edge, one near the bead and one between them, whose bending stiffnesses in a meridian plane are lower than that of the remainder of the sidewall, and the section midline of each sidewall over substantially the whole of its length is convex to the tire interior, each said sidewall being such that it is constrained in compression between the lateral edge of the annular tread reinforcing structure and the associated bead seat on the wheel rim on inflation of the tire and under service conditions.

The reference 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 tire the inflation pressure in the tire is urging the sidewalls axially outwardly reducing their inward curvature. The side-

[Price 33p]

Price 75p

wall 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, therefore, is to compress the sidewalls between the tread reinforcement and the wheel rim.

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 and having a unitary thickness measured in the circumferential direction of the tire, 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 zones of said sidewall outside said low stiffness zones does not exceed the value of 0.6 and is advantageously in the range 0.6 to 0.01.

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 modulus e.g. 40 Kg/cm² which is comparatively high for a sidewall rubber and which may have a modulus higher 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 beads can be wholly of rubber e.g. the same rubber as the sidewall.

However, it is possible to use various materials having different moduli of elasticity for instance a compound having a relatively low modulus at the zones 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 at the zones of greater bending stiffness or a compound having a relatively low modulus at the zones of lower bending stiffness and a compound containing reinforcing fillers or other reinforcing materials such as fibres, oriented, if desired in a preferred manner, at the zones of greater bending stiffness.

In the present specification, the expression "modulus of elasticity" of 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 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 tread annular reinforcement and each of the two sidewalls is in the range 20° to 60°.

The invention will now be described, by way of example only, with reference to the accompanying drawing, which represents in section a deflated tire according to the invention.

The drawing shows in cross-section of a deflated tire comprising a tread band 17, an annular reinforcing structure 18, two sidewalls 19 and 20 and two beads 21 and 22.

The tire is mounted on a rim 23, having flanges 24 and 25, and provided with a normal inflation valve 26.

The annular reinforcing structure 18 extends axially to beyond the section midlines of the sidewalls and 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 18 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 of the tire 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 tire.

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 18 ex-

tends axially for the whole upper portion of the tire, including also the extreme lateral zones of the latter which are respectively connected to the sidewalls 19 and 20. The annular structure 18 and tread band 17 are curved in cross-section so that between the sidewalls the tread arches radially outwardly.

Since the annular structure 18 is substantially inextensible, the average distance between the two lateral edges of said annular reinforcing structure and the flanges 24 and 25 of the rim 23 can be considered as substantially invariable, since each point of said edges belongs to an inextensible circle and each point of said flanges belongs to an incompressible circle.

In the tire illustrated by way of example in the drawing in which the maximum axial width is 150 mm, the distance between the lateral edges of the annular reinforcing structure and the flanges is 30 mm; in the same tire the section height is 70 mm.

In the preferred embodiment illustrated in the figure, the annular reinforcement 18, at the zones of connection with the sidewalls 19 and 20, has a transverse curvature whose concavity is directed towards the tire inside; the tangent to the profile of said structure in such zones of connection forms with the horizontal axis XX, parallel to the axis of rotation of the tire, an angle α of 40° .

These sidewalls, whose section midlines are indicated by lines 27 and 28, show typically a curvature whose convexity is directed towards the tire inside, and their total length at the section midline is considerably greater than the maximum distance existing between the lateral edges of the annular reinforcing structure 18 and the flanges 24, 25 at the maximum eccentricity admissible between the reinforced tread and the rim, so that the convexity directed towards the tire inside is always maintained, and the three zones of lower bending stiffness in the meridian plane act substantially as hinges.

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 side wall a series of circles are inscribed tangential to the interior surface and the exterior surface, the line which joins the centres of the circles forms the section midline.

Considering the tire structure in further detail, six typical zones can be seen between the annular reinforcement 18 and the wheel rim 24; the zone 29, connecting said sidewall to the upper portion of the tire, the zones 30, 32 and 34 having a bending stiffness, in the meridian plane, of a value lower than that of the adjacent zones 31 and 33 and the zone 21 which constitutes the tyre bead. As said above, zones 29 and 21 belong respectively to

inextensible and incompressible circles; therefore they define points whose average distance, on the whole contour of the tire, is substantially invariable.

For this reason, when the inflation air is admitted in the tire, the sidewalls 19 and 20 will be urged outwardly by the inflation pressure. However, the bulk and stiffness of the sidewall will be such as to maintain the convexity of the section midline directed towards the inside, so that the sidewalls are constrained between the edges of annular reinforcing structure 18 and the bead seats and placed under compression reacting through said zones 21 and 29.

For instance, the sidewalls can be wholly constituted of a rubber compound having a modulus of elasticity of about 40 Kg/cm². On account of the thicknesses adopted for the zones 30, 31, 32, 33 and 34, the ratio between the bending stiffnesses of the zones 30 and 31 is equal to 0.39; said ratio, between the zones 34 and 33, is equal to 0.51, whilst the ratio between the bending stiffness of the zone 32 and that of the zone 31 (or of the zone 33) is equal to 0.21.

Moreover, the sidewall compounds can contain short fibres of a material having a modulus of elasticity higher than the rubber compound itself, e.g. glass fibres orientated in a preferred manner, so as to modify in the desired zones the features of bending stiffness and/or resistance to compression. For example, the zones of the sidewalls which have greater bending stiffness may be reinforced in this way.

The beads of the tire may, if desired, contain an annular reinforcing core, but since the sidewalls of the tire operate in compression the possibility arises of dispensing with bead cores and making the beads wholly of rubber.

The advantages offered by the tire according to this invention are many. For example, the sidewalls need not contain continuous reinforcing structures and can, if desired, be made wholly of rubber and therefore can be obtained by means of a simple pouring or injection moulding process, or the like.

This results in economic advantages, owing to the possibility of a higher degree of mechanization with respect to the present technique of construction of normal tires and to possibilities for greater uniformity of production.

Further, owing to the particular configuration of the tire according to the present invention, and in particular to that of its sidewalls, in the event of a puncture, with the consequent drop of pressure, the tire does not collapse completely, and its sidewalls are able to bear, even if at reduced speed and for a relatively short run, the load of the vehicle, without the risk of com-

plete destruction of the tire and with 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 normal tires is increased both the radial stiffness and the transverse stiffness are also 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 better lateral stability of the tire, it is necessary to accept reduced ride comfort.

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 wheel rim.

Reference is made to our U.K. Patent Application No. 33916/72 (Serial No. 1,396,428) which, in common with the present Application, relies for priority on the disclosure of Italian Patent Application No. 83 673 A/71.

WHAT WE CLAIM IS:—

1. A pneumatic tire having a tread reinforced by an annular structure substantially inextensible, when the tyre is inflated in its transverse and circumferential directions and two sidewalls comprising elastomeric material extending from the lateral edges of the tread and terminating in beads able to fit firmly on the bead seats of a rigid wheel rim, in which each sidewall includes three portions, one near to the tread edge, one near the bead and one between them, whose bending stiffnesses in a meridian plane are lower than that of the remainder of the sidewall, and the section midline of each sidewall over substantially the whole of its length is convex to the tire interior, each said sidewall being such that it is constrained in compression between the lateral edges of the annular tread reinforcing structure and the 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 as claimed in claim 1, 2 or 3 in which the ratio between the bending stiffness at least at one of said low stiffness portions of each sidewall and the bending stiffness of the portions of said sidewall not in said low stiffness portions does not exceed a value of 0.6.

5. A pneumatic tire as claimed in claim 4, in which said ratio is in the range 0.6 to 0.01.

6. A pneumatic tire as claimed in any of the preceding claims, in which the various values of bending stiffness are obtained by imparting different thicknesses to different parts of the sidewall.

7. A pneumatic tire as claimed in any of the preceding claims, in which the various values of bending stiffness are obtained using materials having different moduli of elasticity.

8. A pneumatic tire as claimed in claim 7, in which the sidewall portions of lower bending stiffness are constituted by a compound having a modulus of elasticity, in the range 5 to 60 Kg/cm², whilst the sidewall portions of greater bending stiffness are constituted by a compound having a modulus of elasticity, in the range 20 to 150 Kg/cm².

9. A pneumatic tire as claimed in any one of claims 1 to 8 in which each sidewall is made wholly of rubber which has a higher modulus than that of the tread rubber.

10. A pneumatic tire as claimed in claim 9 in which each sidewall and bead is made wholly of rubber which has a higher modulus than the tread rubber.

11. A pneumatic tire as claimed in claim 7, in which the sidewall portions of greater bending stiffness are constituted by a compound incorporating short fibres of a material having a modulus of elasticity higher than that of the compound itself.

12. A pneumatic tire as claimed in claim 11, in which said fibers are made of glass and are orientated in a preferred manner.

13. A pneumatic tire as claimed in any one of the preceding claims, in which at least 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.

14. A pneumatic tire as claimed in claim 13, 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°.

15. A pneumatic tire as claimed in 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.

16. A pneumatic tire as claimed in claim 15 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.

17. A pneumatic tire as claimed in any one of claims 1 to 9 in which the beads

plete destruction of the tire and with 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 normal tires is increased both the radial stiffness and the transverse stiffness are also 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 better lateral stability of the tire, it is necessary to accept reduced ride comfort.

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 wheel rim.

Reference is made to our U.K. Patent Application No. 33916/72 (Serial No. 1,396,428) which, in common with the present Application, relies for priority on the disclosure of Italian Patent Application No. 83 673 A/71.

WHAT WE CLAIM IS:—

1. A pneumatic tire having a tread reinforced by an annular structure substantially inextensible, when the tyre is inflated in its transverse and circumferential directions and two sidewalls comprising elastomeric material extending from the lateral edges of the tread and terminating in beads able to fit firmly on the bead seats of a rigid wheel rim, in which each sidewall includes three portions, one near to the tread edge, one near the bead and one between them, whose bending stiffnesses in a meridian plane are lower than that of the remainder of the sidewall, and the section midline of each sidewall over substantially the whole of its length is convex to the tire interior, each said sidewall being such that it is constrained in compression between the lateral edges of the annular tread reinforcing structure and the 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 as claimed in claim 1, 2 or 3 in which the ratio between the bending stiffness at least at one of said low stiffness portions of each sidewall and the bending stiffness of the portions of said sidewall not in said low stiffness portions does not exceed a value of 0.6.

5. A pneumatic tire as claimed in claim 4, in which said ratio is in the range 0.6 to 0.01.

6. A pneumatic tire as claimed in any of the preceding claims, in which the various values of bending stiffness are obtained by imparting different thicknesses to different parts of the sidewall.

7. A pneumatic tire as claimed in any of the preceding claims, in which the various values of bending stiffness are obtained using materials having different moduli of elasticity.

8. A pneumatic tire as claimed in claim 7, in which the sidewall portions of lower bending stiffness are constituted by a compound having a modulus of elasticity, in the range 5 to 60 Kg/cm², whilst the sidewall portions of greater bending stiffness are constituted by a compound having a modulus of elasticity, in the range 20 to 150 Kg/cm².

9. A pneumatic tire as claimed in any one of claims 1 to 8 in which each sidewall is made wholly of rubber which has a higher modulus than that of the tread rubber.

10. A pneumatic tire as claimed in claim 9 in which each sidewall and bead is made wholly of rubber which has a higher modulus than the tread rubber.

11. A pneumatic tire as claimed in claim 7, in which the sidewall portions of greater bending stiffness are constituted by a compound incorporating short fibres of a material having a modulus of elasticity higher than that of the compound itself.

12. A pneumatic tire as claimed in claim 11, in which said fibers are made of glass and are orientated in a preferred manner.

13. A pneumatic tire as claimed in any one of the preceding claims, in which at least 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.

14. A pneumatic tire as claimed in claim 13, 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°.

15. A pneumatic tire as claimed in 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.

16. A pneumatic tire as claimed in claim 15 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.

17. A pneumatic tire as claimed in any one of claims 1 to 9 in which the beads



each contain an inextensible reinforcing core.

18. A pneumatic tire substantially as described herein with reference to, and as illustrated in, the accompanying drawing.

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