PATENT SPECIFICATION (11) 1 603 590

1 603 590

(21) Application No. 18888/78 (22) Filed 11 May 1978 (19)

(31) Convention Application No. 25019 (32) Filed 24 Jun. 1977 in

(33) Italy (IT)

(44) Complete Specification Published 25 Nov. 1981

(51) INT. CL.[3] B60C 3/00 9/18

(52) Index at Acceptance
B7C RC

(54) IMPROVEMENTS IN OR RELATING TO TYRES

(71) We, INDUSTRIE PIRELLI, Società per Azioni, an Italian Company of Piazzale Cadorna 5, 20123 Milan, Italy, formerly 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 concerns pneumatic tyres for vehicle wheels, and more precisely it refers to pneumatic tyres of the type forming the subject-matter of Italian Patent No. 928,502 (equivalent to U.K. Patent No. 1,396,428) of the present Applicant; in particular, the invention relates to the annular reinforcing structure inserted in said tyre in a radially inner position with respect to the tread.

The pneumatic tyres of the above indicated type have a generally trapezoidal section and show a top portion, generally convex towards the outside - a part of which acts as a tread - which is larger than any other part of the tyre and is provided with a generally annular, substantially circumferentially and axially inextensible reinforcement, and two sidewalls which connect said top portion with the tyre beads, said sidewalls being spread out from the beads as far as the zone of connection to the top portion and having a convexity directed towards the tyre inside; said sidewalls, when the tyre is in inflated condition, being in a state of compression. (By "trapezoidal section" is meant that the above type of tyre has a cross-section, as taken in a radial plane containing the axis of rotation, which in general terms is a four-sided figure having two side parallel. In this case the parallel sides are the tread region and an imaginary line joining its beads.

In the tyres described in the above cited Italian Patent No. 928,502 of the present Applicant and in analogous tyres described in other patents of the Applicant, said sidewalls show moreover thinner portions in their respective zone of connection to the top portion, and preferably also in proximity of the beads.

Said thinner portions act as imperfect hinges, allowing the occurrence of mutual rotations of the parts adjacent to them, due to flexion stresses of said parts.

In the present specification and except upon contrary indications, the expression "flexion stresses" means the stresses referred to the radial section of the tyre, namely those related to flexions in consequence of which each element of the tyre moves in the plane of the radial section containing it.

The above indicated annular reinforcing structure is in general constituted by a plurality of superimposed layers of rubberised cords, the cords of each layer being mutually parallel within any layer and angled with respect to cords of adjacent layers; the cords of each layer can also be formed of various materials, as for instance textile or metallic materials, or materials of other nature, and cords of different layers can be made of analogous or of different materials according to required purposes.

It is known that said annular reinforcing structure plays an important role on the general behaviour of the tyre in use, since it has a considerable influence on several operation characteristics, as for instance tread wear, road traction, road holding, resistance to lateral thrust, comfort and so on.

In fact, even though the tyre part which actually comes into contact with the ground is the tread, it is however said annular reinforcing structure which withstands the deformations suffered by the tyre in use.

It has been already said that the tread constitutes only a part of the top portion; more precisely, the central part, normally

comprising from 0.6 to 0.8 of the total width, which is in contact with the ground during the rectilinear travel of the vehicle, constitutes the true tread, whilst the marginal parts of the top portion come only occasionally into contact with the ground, and may even come never in contact with it.

Said marginal parts, which will be called shoulders, are subjected in use to considerable flexion stresses with respect to the tread which, on the contrary, flattens on the ground during the vehicle running; in fact, the load is applied on the shoulders through the reaction exerted by the sidewalls which are in a substantial compression state.

Moreover, a joint-type connection should theoretically take place in said zones between the top portion and the sidwall; in other words, the parts of the top portion and of the sidewall which join together, although they are free to move and rotate in the space, should remain in a substantially constant mutual angular relationship.

In tyres of this kind this can be allowed, up to a certain point, by the above indicated imperfect hinges, namely by thinner zones or anyhow zones of reduced bending stiffness situation in the sidewalls and in particular in the zone of connection of the sidewall to the top portion, but even out of said zone.

Notwithstanding this, the sidewalls and the top portion are pushed to rotate the one with respect to the other in the connection zones, whilst, for a good performance of the tyre, it is desirable to reduce said rotation to a minimum.

The above indicated flexion stresses, to which the shoulders and the zones of connection of the sidewalls are subjected, have as a consequence that in said parts of the tyre a particular importance is assumed by the bending stiffness of the reinforcement, in addition, of course, to the main requisite of its substantial inextensibility in circumferential and axial direction.

This bending stiffness of the reinforcment is obtained for instance, according to one of the embodiments (corresponding to published Federal German O.L.S. 27 03 172 illustrated in Italian Patent Application No. 19 565 A/76 filed on the 26th January, 1976, by the present Applicant), by folding the ends of the annular reinforcing structure about a reinforcing element constituted for instance by a plurality of cords, or by a body of any shape made of elastomeric material and reinforced with glass fibres or with any other suitable material intended to increase its rigidity.

On the other hand, the evident signs of the serious strain suffered by the tyre shoulders after a certain period of use, in spite of the presence of an annular reinforcing structure stiffened in this way, are clearly indicative of the fact that said structure is not sufficient, by itself, to prevent said flexion stresses in the shoulders and that the solution of the problem is related to other still unknown characteristics.

Accordingly, the present invention provides a pneumatic tyre for motor vehicles, having a generally trapezoidal transverse cross-section and provided with a top portion generally convex towards the outside of and wider than any other part of the tyre, and with two sidewalls, spreading out from the beads as far as the relative zones of connection to said top portion, which sidewalls show a convexity directed towards the inside of the tyre and which are in conditions of compression when the tyre is inflated, said top portion having a central tread part which is normally in contact with the ground at the impression area when the tyre is in use, and lateral shoulders, which are normally not in contact with the ground when the tyre is in use and during rectilinear running of the vehicle, said sidewalls having, at least in proximity of the zones of connection to said shoulders, a section of lesser bending stiffness in comparison with the central part of the sidewall and of the shoulder able to form a hinge, said top portion comprising a generally annular reinforcing structure which is substantially inextensible in axial and circumferential directions and is folded at its ends about reinforcing annular straps, arranged in said shoulders, the tyre being characterised in that in any radial section the "cincture connection angle" (as hereinafter defined) is in the range $-10°$ to $+40°$, the angle lying in a radially inner position with respect to the line, parallel to the tyre axis, taken as reference, being negative.

This "cincture connection angle" and other characteristic angles referred to in this specification are now more exactly defined together with other non-angular parameters. In this specification, the following definitions are employed:-

1) The angle formed by the straight line joining the centres of said hinge, in proximity of the shoulder, and of said strap with a first reference straight line passing through the centre of said hinge and parallel to the tyre axis; this parameter is defined as "cincture connection angle",

2) The angle formed with said first reference straight line by the straight line tangent to the radially innermost profile of the annular reinforcing structure at the point in which the latter is intersected by the plane normal to the tyre axis and tangent to the inner surface of the tyre in the axially outermost point; this parameter is defined as "cincture edge angle",

3) The angle formed by the straight line joining the geometric centres of the hinge in

proximity of said shoulder and of an analogous hinge in proximity of the bead with a second reference straight line, parallel to said first reference straight line and passing through said hinge in proximity of the bead; this parameter is defined as "sidewall angle",

4) The distance, measured on the centre plane "m" between the radially inner surface of the top portion and the theoretical cylindrical surface, coaxial with the tyre, separating the beads from the sidewalls; said distance is defined as "section height", and

5) The distance, still measured on said centre plane, between the radially inner surface of the top portion and the theoretical cylindrical surface, coaxial with the tyre, tangent to the radially inner end of the annular reinforcing structure; said distance is defined as "cincture camber".

According to a series of convenient practical embodiments, the tyre - with the "cincture connection angle" as geometrically delimited above - shows moreover, on the same radial section, the following characteristics, either separately or in combination with one another:

a) cincture edge angle ranging from 10° to 60°,

b) sidewall angle ranging from 30° to 60°,

c) ratio between the cincture chamber and the section height ranging between 0.3 and 0.6.

In pneumatic tyres having the above indicated geometrical characteristics both the annular reinforcing structure and the strap can be conveniently carried out in the different embodiments hereinafter described, obtaining considerable economical advantages and moreover an improvement of all the qualitative features concerning life and behaviour of the tyre in use.

Embodiments of the present invention will now be described by way of example, with the aid of the following description and of the attached drawings, in which:

Figure 1 shows in radial section the tyre according to the invention, bringing into evidence its constituting elements and the above defined typical parameters;

Figures 2, 3, 4 and *5* illustrate, in the tyre of Figure 1, different examples of embodiment of the strap and of the edge of the annular reinforcing structure.

With reference to Figure 1, which represents the tyre mounted on the rim but not yet inflated - being said tyre symmetrical with respect to the centre plane "m" whose path is indicated on this Figure - the right half shows the constituting elements and the left half the typical parameters, the transfer of the data from one half to the other being obviously easy.

The tyre in question comprises a top portion C, generally convex towards the outside and two sidewalls F connecting said top portion to the beads T intended to lock the tyre on the rim R.

The top portion comprises a central part 1, called the tread, which is normally into contact with the ground when the tyre is in use, at the contact area, and two lateral parts 2, called shoulders, which are only exceptionally, and in some points never, into contact with the ground.

The sidewalls comprise a central part 3 convex towards the inside of the tyre, and two end zones 4 and 5, to be respectively connected with the top portion and with the bead, which - as said above - have a lower bending stiffness and are therefore able to behave with sufficient sensitivity as hinges; the figure brings into evidence the respective centres of said zones, defined by the intersections of the median line of the sidewall with the lines joining the points - respectively on the inner and outer surfaces of the sidewall - situated at the minimum mutual distance.

The top portion contains, in a radially inner position, an annular reinforcing structure 6, whose ends are folded about an annular element 7, defined as a strap, which is contained in said shoulders and which constitutes an anchorage for said annular reinforcing structure and at the same time imparts to said annular reinforcing structure the considerable bending stiffness desired in this zone.

As said above, this annular anchorage element can be very conveniently carried out with a plurality of substantially inextensible textile or metallic cords.

Although this is not specifically indicated in the figure, it is anyhow clear that the geometrical centre of said strap, on the section, is easy to locate.

The left half of the figure shows the above defined typical parameters of the tyre. More precisely, they are:

- the cincture connection angle "y" formed by the straight line "s" which joins the centres of the strap and of the hinge in proximity of the shoulder with the reference straight line "r", the angle lying in a radially inner position with respect to said straight line "r" being negative,
- the cincture edge angle "x" formed with the straight line "r" by a straight line "t" tangent to the radially innermost profile of the angular reinforcing structure at point P, in which the plane "p", normal to the tyre axis and tangent to the inner surface of the tyre in the axially outermost point of said inner surface, intersects said profile of the annular reinforcing structure,
- the sidewall angle "w" formed by the straight line "u" joining the centres of the hinges, respectively in proximity of the shoulder and of the bead, with the reference

straight line "r°" passing through the centre of the hinge in proximity of the bead, located as explained above, M and N being the points situated at the minimum distance, analogously to A and B in the hinge in proximity of the shoulder,

- the cincture camber "f", namely the distance, measured on the centre plane "m", between the radially inner surface of the top portion C and the cylindrical surface, coaxial with the tyre, defined in the plane of Figure 1 by its intersection r' tangent to the radially inner end of the annular reinforcing structure, and
- the section height "h", namely the distance, measured on the centre plane "m", between the radially inner surface of the top portion C and the cylindrical surface, coaxial with the tyre, defined in the plane of Figure 1 by its intersection r" separating said beads from said sidewalls.

In the present specification, the above indicated typical parameters are interdependent and their values are variable within the above cited ranges; anyhow, the main parameter is the cincture connection angle "y".

The Applicant has in fact surprisingly ascertained that, irrespectively of the different behaviour and performance of the tyre related to the variability of the other parameters, a considerable improvement of the qualitative feature of the tyre in use and of its service life is anyhow obtained by maintaining said angle "y" within the range of values comprised between and including −10° and + 40° and preferably between 0° and +30°.

Among the pneumatic tyres geometrically identified in this way, very positive results have been obtained with those which have - singularly or in combination - a cincture edge angle comprised between 10° and 60°, a sidewall angle comprised between 30° and 60°, and a cincture camber comprised between 30% and 60% of the section height h.

It is to be here specified that, as regards the cincture edge angle, the straight line "t" is tangent to the radially innermost profile of the annular reinforcing structure 6.

In the tyres having the above indicated characteristics certain practical embodiments both of the annular reinforcing structure and of the strap have proved particularly efficient and appropriate, according to the desired aim and to the tyre properties which it is wished to enhance; said embodiments are illustrated in Figures 2 to 5, which represent the radial section of a tyre shoulder, and in which all reference numerals have been omitted since the location of the constituting elements should be immediately obvious on the basis of the preceding Figure 1.

Considering at first an annular reinforcing structure formed by several superimposed layers, some extended from one strap to the other and others limited to the central part of the top portion, the radially innermost layer of said reinforcing structure must show a curvature without inflections from the centre line of the tyre to the strap, better if the bending radius is laterally outwardly decreasing; moreover, its profile may coincide with the inner profile of the top portion (Figure 2), but may even deviate progressively from it by preceding from the centre line towards the tyre shoulders (Figure 3).

According to a particular version as shown in Figure 2, the reinforcing layer folded about the strap is axially much more extended than the remaining, axially more limited, reinforcing layers superimposed to it so as to create a zone of lesser bending stiffness inserted between the strap and the central part of the annular reinforcing structure; according to another version as shown in Figure 3, affording equally good practical results, the folded portion of said layer, instead of being short, is considerably extended along the underlying structure towards but no further than the nearest end of the remaining layers.

However, the last layer, namely the radially innermost one, may be not folded about the strap (Figure 4); in said case, the latter is wound up in a flipper which forms an integral part of said annular reinforcing structure; which extends axially towards the inside, following approximately the profile of the radially innermost layers towards but no further than, the nearest end of the remaining layers.

As regards the strap, three constructive solutions have proved particularly advisable; they are respectively carried out with a plurality of wires parallel to one another (Figure 4) or with a plurality of wires twisted in a strand (section as in Figure 4) or at least with a plurality of wires joined in one or more layers arranged to form a quadrangular section, in particular a rectangle, having a base parallel (Figure 5), or inclined either way from parallel (not illustrated version) with respect to the tyre axis, within a range of values from −20° to + 20°.

Substantially, the present specification describes several embodiments of constructive particulars of the tyre according to the invention; however, it is clear that the technicians skilled in this field may introduce all the modifications and variations which can be deduced from this specification within the scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS:-

1. A pneumatic tyre for motorvehicles, having a generally trapezoidal transverse cross-section and provided with a top portion generally convex towards the outside of and wider than any other part of the tyre,

and with two sidewalls, spreading out from the beads as far as the respective zones of connection to said top portion, which sidewalls show a convexity directed towards the inside of the tyre and which are in conditions of compression when the tyre is inflated, said top portion having a central tread part which is normally in contact with the ground at the impression area when the tyre is in use, and lateral shoulders, which are normally not in contact with the ground when the tyre is in use and during rectilinear running of the vehicle, said sidwalls having, at least in proximity of the zones of connection to said shoulders, a section of lesser bending stiffness in comparison with the central part of the sidewall and of he shoulder able to form a hinge, said top portion comprising a generally annular reinforcing structure which is substantially inextensible in axial and circumferential directions and is folded at its ends about reinforcing annular straps, arranged in said shoulders, the tyre being characterised in that in any radial section the "cincture connection angle" (as hereinbefore defined) is in the range − 10° to +40°, the angle lying in radially inner position with respect to the line parallel to the tyre axis, taken as reference, being negative.

2. A pneumatic tyre as claimed in Claim 1, wherein said cincture connection angle is in the range 0° to 30°.

3. A pneumatic tyre as claimed in Claim 1 or Claim 2, wherein the cincture edge angle (as hereinbefore defined) is in the range 10° to 60°.

4. A pneumatic tyre as claimed in any of the preceding claims, wherein the sidewall angle (as hereinbefore defined) is in the range 30° to 60°.

5. A pneumatic tyre as claimed in any of the preceding claims, wherein the ratio between its cincture camber (as hereinbefore defined) and the section height (as hereinbefore defined) is in the range 0.3 to 0.6.

6. A pneumatic tyre as claimed in any of the preceding claims, wherein said annular reinforcing structure, in the portion comprised between the two straps, has a curvature without inflections.

7. A pneumatic tyre as claimed in Claim 6, wherein said curvature, in the portion between the tyre centre line and the strap, has a laterally outwardly decreasing bending radius.

8. A pneumatic tyre as claimed in any of the preceding claims, wherein the annular reinforcing structure comprises a plurality of layers, and the profiles of the radially inner surface of said top portion and of the radially innermost layer of said annular reinforcing structure diverge progressively from each other from the tyre centre line towards the shoulders.

9. A pneumatic tyre as claimed in any of claims 1-7, wherein the annular reinforcing structure comprises a plurality of layers, and the portion of the radially innermost layer of the annular reinforcing structure folded about said straps extends axially towards the inside of the tyre, towards but no further than the nearest end of the radially outermost layers of said annular reinforcing structure.

10. A pneumatic tyre as claimed in any of claims 1-7, wherein the annular reinforcing structure comprises a plurality of layers, and said strap is wound up in a flipper which forms part of said annular reinforcing structure and which extends axialy towards the inside of the tyre, following approximately the profile of the radially innermost layer of said annular reinforcing structure towards but no further than the nearest end of the radially outermost layers of said annular reinforcing structure.

11. A pneumatic tyre as claimed in any of the preceding claims, wherein said strap comprises a plurality of metal wires annularly wound up in a strand.

12. A pneumatic tyre as claimed in any of Claims 1 to 10 wherein said strap comprises a plurality of metal wires arranged in one or more superimposed layers.

13. A pneumatic tyre as claimed in Claim 12, wherein said layers are oriented, with respect to the tyre axis, at an inclination ranging from −20° to +20°.

14. A pneumatic tyre substantially as hereinbefore described with reference to and as shown in any one of Figures 1 to 5 of the accompanying drawings.

R.E.S. WALLER,
Agent for the Applicants.

Printed for Her Majesty's Stationery Office,
by Croydon Printing Company Limited, Croydon, Surrey, 1981.
Published by The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.

1603590 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

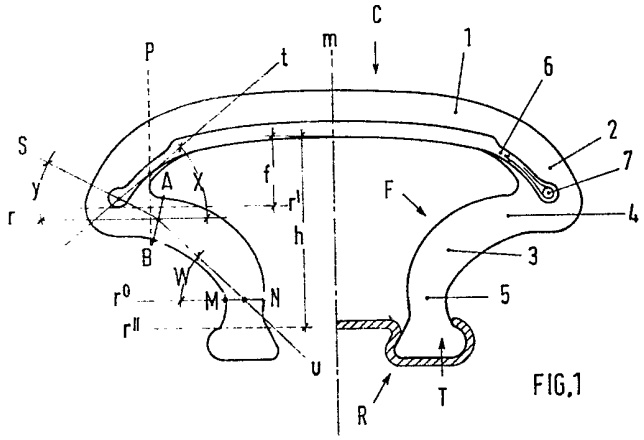

FIG.1

FIG.2

FIG.3

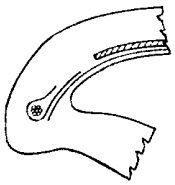

FIG.4

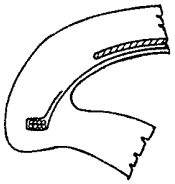

FIG.5