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(54) PNEUMATIC TYRE

(71) We, EUTECO S.p.A., an Italian Joint Stock Company, of 11, via Galiani, 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:

This invention relates to a pneumatic tyre having a carcase comprising at least one ply with cords lying in radial, or substantially radial, planes.

It is known that radial tyres beside the radial carcase, contain a crown reinforcement located between the tyre tread and the carcase, the crown reinforcement being to make the tyre less deformable, and limit its drag against the ground.

The combination of the radial carcase and the crown reinforcement has proved to be very advantageous because, beside a long tread life, it allows good comfort for driving due to the great flexibility of the sides of the tyre or, equivalently, to the low rigidity of the carcase.

The flexibility of the sides does have, however, some negative aspects given that the sides provide only very weak transverse reinforcement when the tyre is stressed by forces in the direction of the axis of rotation. The forces arise, for example, in bends when a centrifugal force develops, acting on the centre of gravity of the vehicle. Furthermore, the accentuated flexibility of the sides makes the strength of the tyre critical in the region of the beads and, more particularly, in the region of the connection between the extremely pliable sides and the beads, which bear on the lateral projections of the mounting rim. These disadvantages are particularly relevant in the case of tyres for industrial motor vehicles because of the high stresses to which they are subject.

It is possible nowadays to manufacture tyres of this kind with only one carcase ply, by means of the use of fabrics with steel cords having very high values of unitary strength. The use of such fabrics with steel cords, together with other reinforcements in the same material, gives satisfactory solutions for the problems regarding tyres for industrial motor vehicles.

Recently new synthetic fabric materials have been prepared such as aromatic polyamides (for example the product known under the registered trade mark "Kevlar") which, as well as having a strength per unit of cross sectional area very close to that of steel, possess an improved resistance to fatigue, render easier and therefore less costly the cutting and preparation of the partly finished product in general, and by reducing the weight of the tyre increase indirectly the driving comfort by a reduction of the so-called "unsprung weight" of the vehicle. The introduction of such materials as reinforcements in tyres has however again raised the problem regarding wear in the region of the beads, previously considered, together with the problem of the lateral stability of the vehicle.

According to the present invention there is provided a pneumatic tyre of the type comprising a crown reinforcement formed by two or more plies and a carcase anchored on each side to a bead wire, the carcase being formed by an inner structure and an outer structure each extending from one bead wire of the tyre to the other;
the inner carcase structure being formed by at least one ply with cords of aromatic polyamide lying in radial, or substantially radial, planes;
and
the outer carcase structure being formed by at least two plies with cords of a material which is not an aromatic polyamide and which has an elongation at break greater than that of the aromatic polyamide, the cords of adjacent plies of the outer carcase structure being arranged to cross one

another and to form angles of from 7° to 35° with the radial planes and equivalent angles of from 14° to 70° between the cords of adjacent plies;

the inner carcase structure being able to bear on its own the inflation pressure of the tyre and the outer carcase structure being able to limit the lateral flexures of the tyre by opposing forces directed along the axis of rotation.

The tyre of this invention which includes said inner carcase structure formed by at least one ply of aromatic polyamide cords may be used for the wheels of vehicles of any kind and permits the elimination, or at least a substantial reduction, of the disadvantages relating to wear in the region of the beads and of the lateral instability.

A fundamental aspect of the tyre of this invention consists in the fact that the carcase is formed by two structures which are different both in the material used and in the function performed. More particularly, the inner structure having the radial, or substantially radial, construction serves as a support structure and supports all, or at least the greater part, of the inflation pressure. The inner structure is formed by at least one ply of aromatic polyamide. Preferably the ply or plies are wrapped around the bead wires and therefore solidly anchored to them.

The outer structure is instead formed by two or more plies having essentially a stabilizing function, inasmuch as it reduces or opposes those lateral flexures of the tyre which take place as the vehicle is driven around a curve. The outer structure is preferably, but not necessarily, formed by an even number of plies, the plies having cords of high extensibility, i.e. formed of material which has a breaking extension, which is much greater than that of the aromatic polyamide.

Preferably the material forming the cords of the outer structure is an aliphatic polyamide (for example to the commercial product "nylon") or any other filamentary material which at loads of from 1/8 to 1/3 of the breaking load, has a greater elongation than that of aromatic polyamide. In particular such elongation should suitably be 2 to 5 times greater than that of the aromatic polyamide.

The cords of adjacent plies of the outer structure are, furthermore, crossed and form angles from 7° to 35° with the radial planes.

The plies forming the outer structure may be wrapped around the bead wires, according to the prior art, or preferably are arranged in the bead regions as described in Patent Application No. 41248/77 (Serial No. 1590784) filed 4th October, 1977. In fact, by working according to Patent Application No. 41248/77 (Serial No. 1590784) it is possible to graduate in a progressive way the flexibility of the joining area between the side and the bead of the carcase. According to a preferred construction according to the invention the ends of the ply or plies of the inner carcase structure are turned back around and anchored to the bead wires and the plies of the outer carcase structure are towards their ends folded back upon themselves to form folds, the folds so formed being located in the respective spaces between the main part of the ply or plies of the inner carcase structure and the turned back parts of the ply or plies of the inner carcase structure or being located outside the turned back parts of the ply or plies of the inner carcase structure.

By making use of the differentiated structures of the carcase of the tyre of this invention it is possible to obtain a significant economy with respect to the known techniques which makes use of a single metal ply and therefore tyres can be obtained which, in working conditions, have an unexpectedly high lateral stability.

Because of the high uniformity of the product, vibrations due to manufacturing imperfections are reduced to the minimum, a considerable reduction of the vibrations caused by the irregularity of the road surface is obtained, with consequent driving comfort, and a considerable lightening of the crown reinforcement is obtained without diminishing the life of the tread of the tyre.

The invention is further illustrated with reference to the accompanying drawings wherein

Figure 1 is a cross-section of half of a penumatic tyre according to the invention;

Figure 2 is a partial side view of the carcase of the pneumatic tyre shown in Figure 1; and

Figures 3 to 11 are cross-sections showing several embodiments of further possible bead configurations of the pneumatic tyre according to Figures 1 and 2.

In Figure 1, which shows half of a pneumatic tyre symmetrical about the plane XX″, are indicated the tread 1 of the tyre provided with grooves 2, the rubber layer of the side wall 3 and the crown reinforcement formed by the two plies 4 and 4′.

The crown reinforcement for the stabilization of the tread of the tyre is superimposed on the carcase and is formed by plies of metal cords, or of other cords, placed so as to form angles from 10° to 25° with respect to the circumferential direction.

In the Figure are also indicated:

– by T the inner structure (drawn with a continuous line), formed by a ply whose cords of aromatic polyamide are arranged in radial planes;

– by L an inner layer, with respect to the ply T, of a mixture of elastomer which

serves to protect the ply from the side of an inner tube in use;

– by S and P (drawn with a broken line) the outer stabilizing structure, able to withstand those forces directed along the axis of rotation of the tyre which tend to flex it laterally.

The plies of the outer structure are formed of materials other than aromatic polyamide and in the specific case are formed by the polyamide known commercially as "nylon".

The direction of the cords of each ply of the outer structure forms an angle of 18° with the radial planes, and in addition the direction of the cords of the ply S crosses that of the cords of the ply P.

All the plies of the inner and outer structures are anchored to the bead wire C, ending with their free edges staggered and more particularly, ply T at T_1, ply S at S_1 and ply P at P_1.

In Figure 1 is also indicated:

– by R a filling of elastomeric mixture to shape the bead.

In the case under discussion ply T is formed by cords of aromatic polyamide having a count of 1670 × 3 decitex, breaking load of 75 Kg, elongation at 25 Kg (i.e. equal to 1/3 of breaking load) of 2.81.

Futhermore the plies S and P forming the outer structure are formed by "nylon" cords with a count of 1400 × 3 decitex, with a breaking load 31.5 Kg and with an elongation at 10.5 Kg (equal to 1/3 of the breaking load) of 10.71.

The stretchability of the cords of the outer structure is therefore 3.8 times greater than that of the cords of the inner structure at loads equal to 1/3 of their breaking loads.

In Figure 2, showing the carcase of the tyre according to Figure 1, as it is seen when the tread, the crown reinforcement and the side wall are in part taken away from the tyre, in the region to the right are schematically indicated the radial cords of ply T forming the inner structure. In the case in question the inner structure is formed by a single ply.

In the centre of the Figure 2 are clearly indicated the cords of ply S which are part of the outer structure. The cords of the ply S are inclined at an angle α equal to 18° with respect to the radial plane represented by the line AA'. On the left of Figure 2 is visible the ply P forming part of the outer structure. The cords of the ply P are also inclined in an angle α equal to 18° with respect to the radial plane represented by the line BB', but have an inclination opposite to those of the ply S. Thus the cords of the two plies S and P form between them an angle 2 α equal to 36°.

In the arrangement shown in Figure 3 ply T, of the inner structure and ply S of the outer structure, are anchored to the bead wire C ending in T_1 and S_1 respectively.

The ply P of the outer structure ends instead at P_1 under the bead wire, thus forming a "closed" arrangement as opposed to the arrangement of Figure 1, which represents an "open" scheme.

In the arrangement shown in Figure 4 the ply T of the inner structure is anchored to the bead wire, while plies S and P of the outer structure end in S_1 and P_1 below the bead wire, thus forming a closed scheme.

In the embodiment of Figure 5 the ply T of the inner structure is anchored to the bead wire, while plies S and P of the outer structure are not anchored and each form a fold by folding of the edge according to Patent Application No. 41248/77 (Serial No. 1590784).

In particular ply S forms a fold ZS between ply T and the ply end T_1; ply P forms a fold ZP placed at a lower level than the bead wire C. Ply P is folded with the flap towards the inside and ply S with the flap towards the outside. The two flaps ending respectively in the free edges S/ and P_1 thus enclose the edge T_1 of ply T.

The arrangement of Figure 6 is similar to that of Figure 5 with the variation that the fold ZP of the ply P, terminates under the bead wire C.

In the embodiment of Figure 7 the folds ZS and ZP of the plies S and P, are between ply T and the relative flap T_1, and in the embodiment of Figure 8 the plies S and P are folded at the edge towards the inside of the carcase and the folds ZS and ZP thus formed are placed outside the flap T_1 of ply T and lie on a lower level than the bead wire C.

Figure 9 shows a bead structure similar to that of Figure 5, in which a ply S folded at the edge forms a fold ZS located between ply T and the respective flap T_1, and ply P which is not folded ends at the edge P_1 between ply S and its associated folded flap S_1.

In the arrangement of Figure 10 ply T, anchored to the bead wire C, is close to the respective flap T_1. Furthermore plies S and P of the outer structure are folded at the ends to form folds ZS and ZP, placed at different levels so as to form, at least in part, a shaped filling of the bead. Lastly R indicates a filling of elastomer placed in the space between ply T and its associated flap.

The arrangement of Figure 11 is similar to that of Figure 5 with a variation due to the fact that ply P of the outer structure is folded with its flap towards the outside. Also, R indicates a filling of elastomer.

The arrangements shown in Figures 7, 9 and 10 can also be completed with elastomeric fillings, placed in a suitable position and able to shape the bead of the carcase, in a manner known in the art.

The structures of the bead can be completed by reinforcements formed by bands of fabric, formed by steel cords or another material, able to provide a graduated flexibility in the region where the side wall and the part of the bead itself housing the bead wire, as is known in the art.

The outer carcase structure may comprise artificial or synthetic cords.

The tyres according to the invention may have different configurations at the two bead wires with the formation of an asymmetric tyre configuration.

WHAT WE CLAIM IS:

1. A pneumatic tyre of the type comprising a crown reinforcement formed by two or more plies and a carcase anchored on each side to a bead wire, the carcase being formed by an inner structure and an outer structure each extending from one bead wire of the tyre to the other; the inner carcase structure being formed by at least one ply with cords of aromatic polyamide lying in radial, or substantially radial, planes; and

the outer carcase structure being formed by at least two plies with cords of a material which is not an aromatic polyamide and which has an elongation at break greater than that of the aromatic polyamide, the cords of adjacent plies of the outer carcase structure being arranged to cross one another and to form angles of from 7° to 35° with the radial planes and equivalent angles of from 14° to 70° between the cords of adjacent plies;

the inner carcase structure being able to bear on its own the inflation pressure of the tyre and the outer carcase structure being able to limit the lateral flexures of the tyre by opposing forces directed along the axis of rotation.

2. A tyre according to claim 1 wherein the ply or plies of the inner carcase structure are all anchored to the bead wires.

3. A tyre according to claim 1 wherein the ends of the ply or plies of the inner carcase structure are turned back around and anchored to the bead wires and the plies of the outer carcase structure are towards their ends folded back upon themselves to form folds, the folds so formed being located in the respective spaces between the main part of the ply or plies of the inner carcase structure and the turned back parts of the ply or plies of the inner carcase structure or being located outside the turned back parts of the ply or plies of the inner carcase structure.

4. A tyre according to any one of claims 1 to 3 having different configurations at the two bead wires with the formation of an asymmetric tyre configuration.

5. A tyre according to any one of the preceding claims wherein the cords of the crown reinforcement plies are arranged at angles of 10° to 25° to the circumferential direction.

6. A pneumatic tyre constructed and arranged substantially as described with reference to and as illustrated in the accompanying drawings.

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1590785 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG. 1

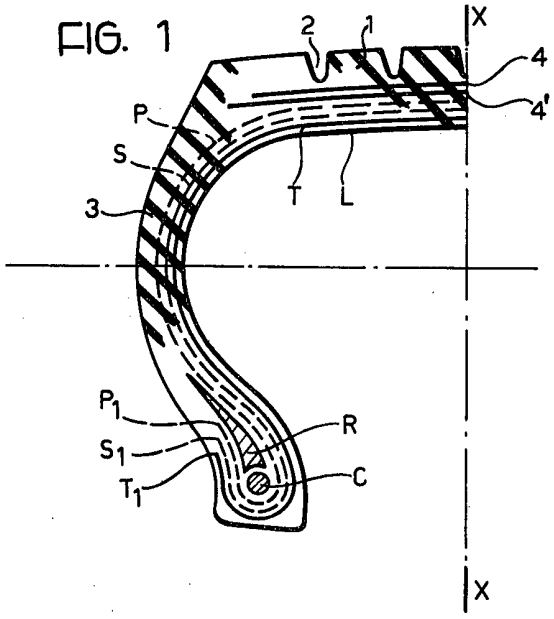


FIG. 2

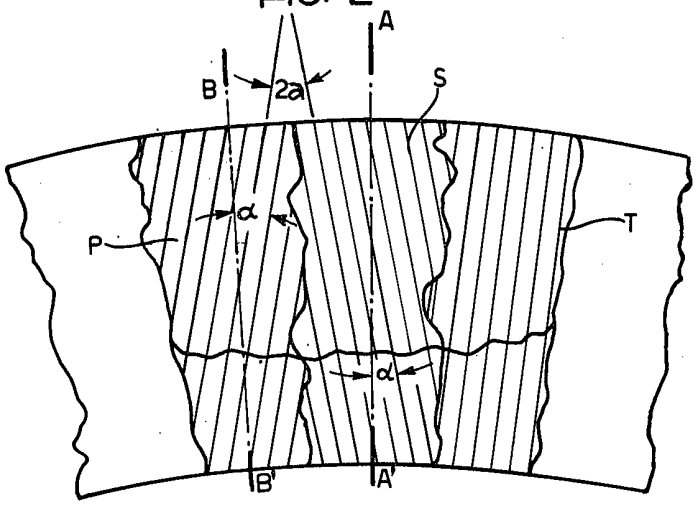


FIG. 3

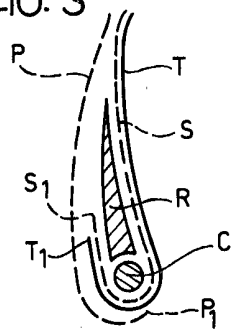


FIG. 4

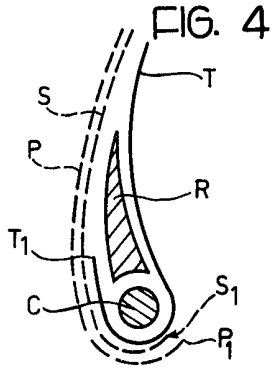


FIG. 5

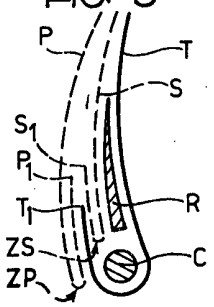


FIG. 6

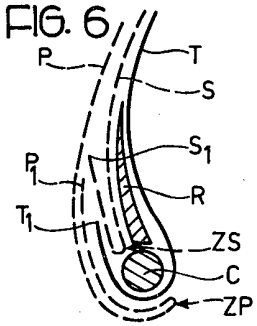


FIG. 7

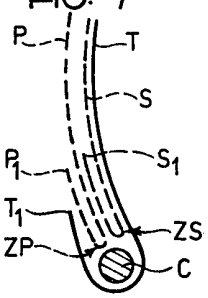
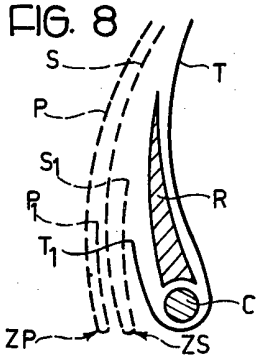


FIG. 8



1590785 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3

FIG. 9

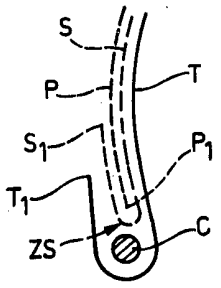


FIG. 10

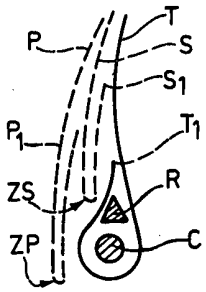


FIG. 11