

I, John Andrew, am fluent in English and Japanese. I hereby certify under penalty of perjury that I translated into English the following document: Japanese Patent Application No. 2007216778A, published on August 30, 2007, which is attached to this Affidavit. I further certify and verify under penalty of perjury that the attached document written in English is, to the best of my knowledge, a true and accurate English translation of Japanese Patent Application No. 2007216778A, published on August 30, 2007, which is written in Japanese.



\_\_\_\_\_ (Signature of Translator/Verifier)

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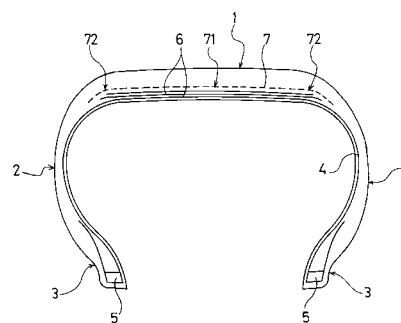
(54) [Title of invention] Pneumatic radial tires

(57) [Summary] (With correction)

[Problem to be solved] To provide a pneumatic radial tire for a passenger car that makes it possible to obtain a higher level of high-speed durability and high-speed handling stability.

[Means for solving the problems] The pneumatic radial tire has an organic fiber reinforced cover layer 7 wound around the radial outside of the belt layer 6 at approximately 0 degrees with respect to the tire circumferential direction, the organic fiber reinforced cover layer being made up of a center cover layer 71 and a shoulder cover layer 72, and the ratio of the width of the center cover layer to the overall width of the organic fiber reinforced cover layer is 30 to less than 90%.

[Selection Diagram] FIG. 1



[Scope of patent claims]

[Claim 1]

A pneumatic radial tire having an organic fiber reinforced cover layer wound around the radial outside of a belt layer at approximately 0 degrees with respect to the tire circumferential direction, the organic fiber reinforced cover layer being composed of a center cover layer as described below in A and a shoulder cover layer as described below in B, and the ratio of the width of the center cover layer to the total width of the organic fiber reinforced cover layer is 30% or more and less than 90%.

(A) Center cover layer: The cover layer is disposed near the center of the tire in the axial direction and is constructed using a three-ply composite cord formed by twisting two high-elasticity yarns and one low-elasticity yarn in the same direction, and then twisting them together in the opposite direction to the direction of the first twist.

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(B) Shoulder cover layer: A cover layer is disposed near the edge of the belt layer and is constructed using a two-ply composite cord formed by twisting together one high elasticity yarn and one low elasticity yarn that are each twisted in the same direction.

[Claim 2]

The pneumatic radial tire according to Claim 1 is characterized in that the twist coefficient  $K_c$  of the cords of the center cover layer and the twist coefficient  $K_{sh}$  of the cords of the shoulder cover layer satisfy the following formulas (a) and (b), respectively.

Center cover layer cord twist coefficient  $K_c \geq 1600$  ... Formula (a)

Shoulder cover layer cord twist coefficient  $K_{sh} \leq 2250$  ... Formula (b)

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Here,

Center cover layer cord twist coefficient  $K_c = T_c \times \sqrt{D_c}$

Shoulder cover layer cord twist coefficient  $K_{sh} = T_{sh} \times \sqrt{D_{sh}}$

$T_c$ : Number of twists of the center cover layer cord (twists/10cm)

$D_c$ : Total nominal fineness (dtex) of the center cover layer cord

$T_{sh}$ : Number of twists of the shoulder cover layer cord (twists/10cm)

$D_{sh}$ : Total nominal fineness (dtex) of the shoulder cover layer cord

[Claim 3]

The pneumatic radial tire according to Claim 1 or 2 is characterized in that the twist coefficient  $K_c$  of the cords of the center cover layer and the twist coefficient  $K_{sh}$  of the cords of the shoulder cover layer satisfy the following formulas (c) and (d), respectively.

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$1,600 \leq K_c \leq 2,250$  ..... Formula (c)

$1,600 \leq K_{sh} \leq 2,250$  ..... Formula (d)

[Claim 4]

The pneumatic radial tire according to Claim 1, 2 or 3 is characterized in that the high elasticity yarn has an elastic modulus of 200 cN/dtex or more and is made of any one of aramid fiber, polyolefin ketone (POK) fiber and polybenzoxazole (PBO) fiber, and the low elasticity yarn has an elastic modulus of 150 cN/dtex or less and is made of aliphatic polyamide fiber.

[Claim 5]

The pneumatic radial tire according to Claim 1, 2, 3 or 4, further comprises of an auxiliary fiber reinforcement layer using polyester fiber or aliphatic polyamide fiber disposed radially outward of the organic fiber reinforcement cover layer and in the vicinity of the center in the axial direction of the tire.

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[Detailed description of the invention]

[Technical field]

[0001]

The present invention relates to a pneumatic radial tire, and more particularly to a pneumatic radial tire that exhibits excellent performance in high-speed durability and high-speed handling stability as a tire for a passenger car.

[Background Technology]

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[0002]

It is known that in pneumatic radial tires for automobiles, particularly passenger cars, the use of a highly elastic belt cover material made of fiber cords with high elasticity properties suppresses the upward deformation of the crown caused by the centrifugal force accompanying tire rotation, resulting in a stable ground contact shape, and that the realization of this stable ground contact shape results in improved high-speed durability and high-speed steering stability.

[0003]

Conventionally, aramid fiber cords, polyethylene naphthalate (PEN) fiber cords, aramid fiber/nylon 66 fiber hybrid cords, and nylon 66 fiber cords, etc. have been known as fiber materials with high elasticity properties that are used for such highly elastic belt cover materials, and each of these has been used taking advantage of their respective advantages.

[0004]

Among these, especially in the high speed range, hybrid cords of aramid fiber/nylon 66 fiber are generally superior in terms of rigidity, fatigue resistance, low heat generation characteristics, and heat shrinkage, and belt cover materials using hybrid cords of aramid fiber/nylon 66 fiber are often used.

[0005]

Here, the hybrid cord refers to a cord formed by twisting two or three different types of cords together, and the aramid fiber/nylon 66 fiber hybrid cord refers to a cord in which a total of two or three aramid fiber cords and nylon 66 fiber cords, each of which is twisted (z twist), are used and twisted together (s twist) to form a single reinforcing cord.

[0006]

However, there is still room for improvement in aramid fiber/nylon 66 fiber hybrid cords. For example, two-stranded cords have poor fatigue resistance under compression, which causes problems with compression fatigue in the center of the tire, and it cannot be said that tire durability has been improved sufficiently. Furthermore, in the case of a three-stranded cord, the overall cord diameter is generally large and the ply gauge is thick, which results in a large number of heating elements and makes the shoulder portions more susceptible to heat accumulation. This is a disadvantage in terms of tire durability and makes the cord less than satisfactory.

[0007]

As described below, the present invention involves dividing the belt cover material into a center portion and a shoulder portion, and using different cover cords in each portion. However, in the background technology, there are proposals such as using different cover cords in the center portion and the shoulder portion, in particular making the residual tension of the covers different from each other (Patent Literature 1), making the thermal shrinkage rate and elastic modulus of the covers different from each other (Patent Literature 2), making the rigidity of the covers different from each other (Patent Literature 3), or making the modulus different from each other (Patent Literature 4).

[0008]

However, these methods all differ from the present invention in terms of both technical concept and specific configuration, and in particular, they do not focus on the lower twist and upper twist structure when forming a hybrid cord as in the present invention described below.

[0009]

[Patent Literature 1] Japanese Unexamined Patent Application No. 6-297910

[Patent Literature 2] Japanese Unexamined Patent Application No. 7-215011

[Patent Literature 1] Japanese Patent Application Publication No. 2002-356103

[Patent Literature 4] Japanese Patent Application Publication No. 2005-263137

[Disclosure of invention]

[Problems to be solved by the invention]

[0010]

In view of the above, the present invention aims to provide a pneumatic radial tire for automobiles, particularly passenger cars, that further improves the high-speed durability and high-speed steering stability that are achieved based on the good and stable ground contact shape realized with the conventional belt cover material using aramid fiber/nylon 6,6 fiber hybrid cord, thereby making it possible to obtain a higher level of high-speed durability and high-speed steering stability.

[Means for solving the problems]

[0011]

The pneumatic radial tire of the present invention that achieves the above-mentioned object has the following configuration (1).

(1) A pneumatic radial tire having an organic fiber reinforced cover layer wound around the radial outside of a belt layer at approximately 0 degrees with respect to the tire circumferential direction, the organic fiber reinforced cover layer being composed of a center cover layer as described below in A and a shoulder cover layer as described below in B, and the ratio of the width of the center cover layer to the total width of the organic fiber reinforced cover layer is 30% or more and less than 90%. 10

(A) Center cover layer: The cover layer is disposed near the center of the tire in the axial direction and is constructed using a three-ply composite cord formed by twisting two high-elasticity yarns and one low-elasticity yarn in the same direction, and then twisting them together in the opposite direction to the direction of the first twist.

(B) Shoulder cover layer: A cover layer is disposed near the edge of the belt layer and is constructed using a two-ply composite cord formed by twisting together one high elasticity yarn and one low elasticity yarn that are each twisted in the same direction.

[0012]

More specifically, the pneumatic radial tire of the present invention is preferably a pneumatic radial tire described in any one of (2) to (5) below.

(2) A pneumatic radial tire as described in (1) above, in which the twist coefficient  $K_c$  of the cords of the center cover layer and the twist coefficient  $K_{sh}$  of the cords of the shoulder cover layer satisfy the following formulas (a) and (b), respectively. 20

Center cover layer cord twist coefficient  $K_c \geq 1600$  ... Formula (a)

Shoulder cover layer cord twist coefficient  $K_{sh} \leq 2250$  ... Formula (b)

Here,

Center cover layer cord twist coefficient  $K_c = T_c \times \sqrt{D_c}$

Shoulder cover layer cord twist coefficient  $K_{sh} = T_{sh} \times \sqrt{D_{sh}}$

$T_c$ : Number of twists of the center cover layer cord (twists/10cm)

$D_c$ : Total nominal fineness (dtex) of the center cover layer cord

$T_{sh}$ : Number of twists of the shoulder cover layer cord (twists/10cm) 30

$D_{sh}$ : Total nominal fineness (dtex) of the shoulder cover layer cord

[0013]

(3) A pneumatic radial tire according to the above (1) or (2), in which the twist coefficient  $K_c$  of the cords of the center cover layer and the twist coefficient  $K_{sh}$  of the cords of the shoulder cover layer satisfy the following formulas (c) and (d), respectively.

$1600 \leq K_c \leq 2250$  ... ... Formula (c)

$1600 \leq K_{sh} \leq 2250$  ... ... Formula (d)

[0014]

(4) The pneumatic radial tire according to (1), (2) or (3) above, wherein the high elasticity yarn has an elastic modulus of 200 cN/dtex or more and is made of one type of fiber selected from aramid fiber, polyolefin ketone (POK) fiber and polybenzoxazole (PBO) fiber, and the low elasticity yarn has an elastic modulus of 150 cN/dtex or less and is made of aliphatic polyamide fiber. 40

(5) The pneumatic radial tire according to (1), (2), (3) or (4) above is further characterized in that an auxiliary fiber reinforcement layer using polyester fiber or aliphatic polyamide fiber is disposed on the outer side of the organic fiber reinforcement cover layer in the tire radial direction and near the center in the tire axial direction.

[Effects of the Present Invention]

[0015]

According to the pneumatic radial tire of the present invention as set forth in Claim 1, a pneumatic radial tire is provided in that, in the pneumatic radial tire for an automobile, particularly for a passenger car, it is possible to further improve the high-speed durability and high-speed steering stability that are obtained based on the good and stable ground contact shape realized by the conventional belt cover material using the hybrid cord of aramid fiber/nylon 66 fiber, thereby making it possible to obtain a higher level of high-speed durability and high-speed steering stability.

[0016]

Furthermore, according to any of Claims 2 to 5, the effect obtained by Claim 1 is made even clearer, and a pneumatic radial tire is provided that makes it possible to obtain a higher level of high-speed durability and high-speed driving stability.

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[Detailed Description of the Preferred Embodiments]

[0017]

The pneumatic radial tire of the present invention will now be described in more detail.

[0018]

The pneumatic radial tire of the present invention is a pneumatic radial tire having an organic fiber reinforced cover layer wound radially outside the belt layer at approximately 0 degrees relative to the tire circumferential direction, and the organic fiber reinforced cover layer is configured to be composed of a center cover layer as described below in A and a shoulder cover layer as described below in B.

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(A) Center cover layer: The cover layer is disposed near the center of the tire in the axial direction and is constructed using a three-ply composite cord formed by twisting two high-elasticity yarns and one low-elasticity yarn in the same direction, and then twisting them together in the opposite direction to the direction of the first twist.

(B) Shoulder cover layer: A cover layer is disposed near the edge of the belt layer and is constructed using a two-ply composite cord formed by twisting together one high elasticity yarn and one low elasticity yarn that are each twisted in the same direction.

[0019]

Furthermore, the ratio of the width of the center cover layer to the overall width of the organic fiber reinforced cover layer is set to 30% or more and less than 90%.

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[0020]

FIG. 1 shows an embodiment of a pneumatic radial tire of the present invention, and is a schematic cross-sectional view taken in the meridian direction of the pneumatic tire, in which 1 is a tread portion, 2 is a sidewall portion, and 3 is a bead portion. A carcass layer 4 made of organic fiber cords arranged at approximately 90 degrees to the tire circumferential direction is embedded inside the tire so as to span the entire tread portion 1, left and right sidewall portions 2, and bead portions 3, and both ends of the carcass layer 4 are folded back from the inside to the outside of the tire around the bead cores 5.

[0021]

On the outer circumferential side (radial outer side) of the carcass layer 4, a belt layer 6 made of steel cords is provided, for example in two layers, and on the outer circumferential side (radial outer side) of the belt layer 6, an organic fiber reinforced cover layer 7 that reinforces the belt layer 6 is provided. The organic fiber reinforced cover layer 7 has a belt-like structure in which a large number of parallel organic fiber cords are generally impregnated with rubber, and the organic fiber cords are wound around the tire at an angle of approximately 0 degrees with respect to the circumferential direction of the tire.

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[0022]

In the present invention, as described above, the organic fiber reinforced cover layer 7 is composed of the center cover layer 71 of A above and the shoulder cover layer 72 of B above. In particular, the center cover layer 71 is composed of a three-strand composite cord in which two high modulus yarns and one low modulus yarn are first twisted in the same direction and then twisted in the opposite direction to the first twist direction. This provides excellent fatigue resistance during compression, thereby improving the high-speed durability of the tire.

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[0023]

On the other hand, since the shoulder cover layer 72 is constructed using a two-ply composite cord formed by twisting together one high elasticity yarn and one low elasticity yarn that are each twisted in the same direction, the ply gauge (ply thickness) can be made thinner, resulting in less heat generating/heat storing material and less heat generated during high-speed driving, which improves high-speed durability.

[0024]

The reason for using high modulus yarns and low modulus yarns in combination in each of the cover layers is to provide a single hybrid twisted cord with a good balance of cord properties such as rigidity, fatigue resistance under compression, heat generation properties, and heat shrinkage properties. For this reason, it is important that the ratio of the width of the center cover layer to the overall width of the organic fiber reinforced cover layer is 30% or more and less than 90%, as described above, and more preferably 45% or more and less than 75%.

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[0025]

Furthermore, the reason why each of the fibers is first twisted in the same direction and then twisted in the opposite direction to the first twist to form a single hybrid twisted cord is that by forming a hybrid twisted cord by applying a second twist in the direction in which the first twist is untwisted, each of the fibers in the cord becomes more parallel to the axial direction of the cord (straighter), thereby allowing the reinforcing and elastic effects of each of the fibers, and ultimately the inherent reinforcing and elastic effects of the fiber cord, to be more fully exerted.

[0026]

Each high modulus yarn and each low modulus yarn used in the present invention do not need to be the same thickness as a single yarn, and it is practical and preferable to have an appropriate difference in thickness (fineness) in order to better utilize the technical effect of the hybrid structure. In particular, in order to make the most of the characteristics of the high modulus yarn, it is preferable that the low modulus yarn has a thickness (fineness) of about 75 to 95% of the thickness (fineness) of the high modulus yarn.

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[0027]

The number of hybrid twisted cords (embedding density) in the center cover layer and the shoulder cover layer is preferably within a range of 40 to 50 ends/50 mm width for the center cover layer, and within a range of 35 to 50 ends/50 mm width for the shoulder cover layer.

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[0028]

The center cover layer and the shoulder cover layer do not necessarily have to be formed as separate layers, but may be formed as a single organic fiber reinforced cover layer that is continuous in the axial direction of the tire. Also, if formed as separate and distinct pieces, they may be spaced apart (distant) from each other at their ends.

[0029]

The high modulus yarn and low modulus yarn used in the present invention may have a relative difference in elastic modulus value within the range of the various organic fibers normally used in constructing a hybrid twisted cord. However, according to the findings of the inventors, in order to satisfactorily utilize the effect of using a high modulus yarn in the reinforcing cover layer, it is more effective and preferable to use a high modulus yarn with an elastic modulus of 200 cN/dtex or more. In order to obtain such an elastic modulus, it is preferable to use yarns made of aramid fibers, polyolefin ketone (POK) fibers, or polybenzoxazole (PBO) fibers.

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[0030]

In addition, the low modulus yarn used in the present invention preferably has an elastic modulus of 150 cN/dtex or less, in that it can more clearly exhibit the same effects of the present invention, and also has a polymer type. It is preferable to use a yarn made of aliphatic polyamide fiber, and specifically, it is preferable to use nylon 66 fiber, nylon 6 fiber, nylon 64 fiber, or the like.

[0031]

In the present invention, it is preferable that the final twist coefficient  $K_c$  of the cords in the center cover layer and the final twist coefficient  $K_{sh}$  of the cords in the shoulder cover layer satisfy the following equations (a) and (b), respectively, so that the desired effects of the present invention can be more clearly obtained.

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Center cover layer cord twist coefficient  $K_c \geq 1600$  ... Formula (a)

Shoulder cover layer cord twist coefficient  $K_{sh} \leq 2250$  ... Formula (b)

Here,

Center cover layer cord twist coefficient  $K_c = T_c \times \sqrt{D_c}$

Shoulder cover layer cord twist coefficient  $K_{sh} = T_{sh} \times \sqrt{D_{sh}}$

$T_c$ : Number of twists of the center cover layer cord (twists/10cm)

$D_c$ : Total nominal fineness (dtex) of the center cover layer cord

$T_{sh}$ : Number of twists of the shoulder cover layer cord (twists/10cm)

$D_{sh}$ : Total nominal fineness (dtex) of the shoulder cover layer cord

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[0032]

In addition, the preferred ranges of the final twist factor  $K_c$  of the cords in the center cover layer and the final twist factor  $K_{sh}$  of the cords in the shoulder cover layers satisfy the following equations (c) and (d), respectively. By keeping them within these ranges, the intended effects of the present invention can be more clearly obtained.

$1,600 \leq K_c \leq 2,250$  ..... Formula (c)

$1,600 \leq K_{sh} \leq 2,250$  ..... Formula (d)

[0033]

Furthermore, the width of the organic fiber reinforced cover layer 7 is preferably within the range of 80% to 110%, and most preferably within the range of 95% to 105%, with respect to the total width of the belt layer 6.

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[0034]

In the present invention, it is also a preferred embodiment that an auxiliary fiber reinforcing layer using polyester fibers (e.g., PEN fibers) or aliphatic polyamide fibers is further disposed on the outer side in the tire radial direction of the organic fiber reinforcing layer and in the vicinity of the center in the tire axial direction. FIG. 2 shows a model of the essential parts of this embodiment, and is a schematic model diagram showing the arrangement of the belt layer 6, the organic fiber reinforced cover layer 7, and the above-mentioned auxiliary fiber reinforcement layer 8 in a meridian cross section of the pneumatic tire as shown in FIG. 1. The organic fiber reinforced cover layer 7 is made up of a center cover layer 71 and a shoulder cover layer 72, and this shows an embodiment in which the auxiliary fiber reinforcement layer 8 having a width smaller than that of the center cover layer is disposed on the outer circumferential side of the center cover layer 7. In this way, by disposing polyester fibers or aliphatic polyamide fibers, which have relatively good fatigue resistance, in the outermost layer, the compression fatigue resistance of the center portion can be further improved, and a pneumatic radial tire with extremely excellent high-speed durability and high-speed fatigue resistance can be realized. The auxiliary fiber reinforcing layer 8 is not particularly limited, but is preferably a rubber-coated layer in which organic fiber cords are arranged in parallel to the tire circumferential direction. However, they may be arranged in a direction intersecting the circumferential direction at an angle.

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[Embodiment]

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[0035]

The specific configuration and effects of the pneumatic radial tire of the present invention will be further described below with reference to the embodiments.

[0036]

The elastic modulus, number of twists, width of the organic fiber reinforcing fiber cover layer, width of the center cover layer and width of the shoulder cover layer used in the description of the present invention were measured by the following methods.

(1) Yarn Modulus:

Based on JIS L1017-2002 "Test Method for Chemical Fiber Tire Cord 8.8 Initial Tensile Resistance", the initial tensile resistance of the yarn before twisting under standard conditions is calculated, and this is regarded as the elastic modulus of the yarn.

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(2) Number of twists:

Based on JIS L1017-2002 "Testing Method for Chemical Fiber Tire Cords 8.4", the number of upper twists and the number of lower twists of the twisted cord were determined.

## (3) Width of center cover layer:

The tire cap tread portion is cut in the radial direction at two locations on the tire circumference, and cut sections having a circumferential length of 15 to 30 mm are taken so that the cross section of the belt portion can be observed.

[0037]

The sampling positions are an arbitrary point A on the tire cap tread portion and a point B located opposite to the tire center point. The width of the center cover layer was measured on a total of four surfaces, two cut sections A and B, and the average was taken as the width of the center cover layer. The width of each center cover layer is determined by the two cords located at the outermost ends in the tire width direction, and is the length measured along the path along other center cover cords located therebetween.

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[0038]

## (4) Width of shoulder cover layer:

For the two cut sections A and B taken in the same manner as the center cover layer, the cross sections were observed (total of 4 sides x 2 locations each), the width of the shoulder cover layer was measured, and the average was taken as the width of the shoulder cover layer. The width of each shoulder cover layer is determined by two cords located at the outermost ends in the tire width direction, and is the length measured along a path along other shoulder cover cords located therebetween.

## (5) Width of organic fiber reinforced fiber cover layer:

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The width of the organic fiber reinforcing fiber cover layer was calculated from the widths of the center cover layer and the shoulder cover layer measured in (3) and (4) above using the following formula.

Width of organic fiber reinforced fiber cover layer = width of center cover layer + (width of shoulder cover layer x 2)

[0039]

In each of the Embodiments and Comparative Examples, an organic fiber reinforcing layer for a pneumatic radial tire was produced using the following various codes A to G. When each cord was manufactured, the first twist direction was the S direction, and the second twist direction was the Z direction.

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## (1) Code A:

A three-ply hybrid cord consisting of 1670 dtex aramid fiber yarn, 1670 dtex aramid fiber yarn, and 1400 dtex nylon 66 fiber yarn.

## (2) Code B:

A two-ply hybrid cord made of aramid fiber 1670 dtex yarn and nylon 66 fiber 1400 dtex yarn.

## (3) Code C:

A three-ply hybrid cord made of 1670 dtex POK fiber yarn, 1670 dtex POK fiber yarn, and 1400 dtex nylon 66 fiber yarn.

## (4) Code D:

A two-ply hybrid cord made of 1670 dtex POK fiber yarn and 1400 dtex nylon 66 fiber yarn.

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## (5) Code E:

A three-ply hybrid cord consisting of 1670 dtex PEN fiber yarn, 1670 dtex PEN fiber yarn, and 1400 dtex nylon 66 fiber yarn.

## (6) Code F:

A two-ply hybrid cord made of 1670 dtex PEN fiber yarn and 1400 dtex nylon 66 fiber yarn.

## (7) Code G:

A three-ply cord made of 1670 dtex PEN yarn/1670 dtex PEN yarn/1670 dtex PEN yarn.

[0040]

Embodiments 1 to 16, Comparative Examples 1 to 10

Using various combinations of yarns shown in Tables 1 to 4, tires for passenger cars were manufactured using an organic fiber reinforced cover layer 7 consisting of a center cover layer and a shoulder cover layer.

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[0041]

In the table, the ratio of the width of the shoulder cover layer to the total width of the reinforcing cover layer is shown as the width of one side of the shoulder cover. The number of cords driven into the center cover layer and the number of cords driven into the shoulder cover layer were both 45 cords/50 mm in width.

[0042]

The passenger car tires thus obtained were subjected to a test for tire durability under high speed running, and the total time until the tire was destroyed was evaluated.

[0043]

In Comparative Example 1, a reinforcing layer consisting only of conventional cord A was used from the center region to the shoulder region (total width 200 mm). The time to failure for Comparative Example 1 was set at 100, and the other comparisons were expressed as an index evaluation, with a larger value indicating a longer time to failure and better tire durability for high-speed driving. 10

[0044]

As shown in Embodiments 1 to 3 in Table 1, the present invention provides good high-speed durability.

[0045]

When the reinforcing layer is formed of the same cover layer over the entire width (center and shoulder portions) as in Comparative Examples 1 and 2 in Table 1, the performance is inferior to that of the present invention. Furthermore, as shown in Comparative Example 3, when a three-ply cord is used in the shoulder and a two-ply cord is used in the center, which is the opposite of the present invention, the high speed durability is considerably inferior. As shown in Comparative Example 4, even when a three-strand cord is used in the center, if the width is too wide, almost no improvement is obtained, and the result is at the same level as Comparative Example 1. Furthermore, as shown in Comparative Example 5, even if a three-ply cord is used in the center, if the width is too narrow, high speed durability is significantly reduced. 20

[0046]

All of the embodiments 4 to 11 shown in Table 2 are according to the present invention and show good results. However, among them, the embodiment 4 with a smaller twist factor had a large twist pitch, but fatigue breakage occurred in the center cord, causing tread peeling. Although the effect of the present invention was clearly observed, it was smaller than the other embodiments (index 105). 30

[0047]

In addition, the Embodiment 11 having a larger twist coefficient had a smaller twist pitch but a smaller rigidity, and the shoulder (edge) portion was not held in place, causing peeling at the shoulder. Although the effect of the present invention was clearly observed, it was smaller than that of the other examples (index 105).

[0048]

Embodiments 12 to 14 shown in Table 3 are all according to the present invention and show good results, using POK fiber as the constituent yarn of the hybrid cord (high elasticity side). 40

[0049]

Comparative Examples 6 to 10 shown in Table 3 use POK fiber as the constituent yarn of the hybrid cord (high elasticity side). However, similar to Comparative Examples 1 to 5, when 100% of the reinforcing cover layer is used (the same for the center and shoulder) or when the usage ratio is inappropriate, the effects of the present invention cannot be obtained.

[0050]

In Embodiment 15 in Table 4, PEN fiber yarn was used as the high-elasticity yarn, and the yarn structure and cord structure were almost the same as those of Embodiment 13. However, the heat generated by the yarn was high, and although the effect of the present invention was clearly observed, it was smaller than that of Embodiment 13 (index 110). 50

[0051]

In Embodiment 16, an auxiliary fiber reinforcement layer made of PEN fiber (Embodiment 8 in FIG. 2 ) was further added to Embodiment 13 to enhance durability. In this embodiment, heat generation due to deformation upon contact with the ground was further suppressed, and high-speed durability was very good (index 130).

[0052]

[Table 1]

	Embodiment 1	Embodiment 2	Embodiment 3	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5
Center cover layer								
Cord structure (yarn combination)	A	A	A	A	B	B	A	A
Total fineness (dtex)	4740	4740	4740	4740	3070	3070	4740	4740
High modulus yarn twist count (twists/10cm)	28	28	28	28	38	38	28	28
Low modulus yarn twist count (twists/10cm)	28	28	28	28	38	38	28	28
Number of twists (twists/10cm)	28	28	28	28	38	38	28	28
Upper twist factor	1928	1928	1928	1928	2105	2105	1928	1928
Driving density (lines / 50 mm)	45	45	45	45	45	45	45	45
Code diameter (mm)	0.9	0.9	0.9	0.9	0.7	0.7	0.9	0.9
Ply gauge (mm)	1.4	1.4	1.4	1.4	1.2	1.2	1.4	1.4
Shoulder cover layer								
Cord structure (yarn combination)	B	B	B	A	B	A	B	B
Total fineness (dtex)	3070	3070	3070	4740	3070	4740	3070	3070
High modulus yarn twist count (twists/10cm)	38	38	38	28	38	28	38	38
Low modulus yarn twist count (twists/10cm)	38	38	38	28	38	28	38	38
Number of twists (twists/10cm)	38	38	38	28	38	28	38	38
Upper twist factor	2105	2105	2105	1928	2105	1928	2105	2105
Driving density (lines / 50 mm)	45	45	45	45	45	45	45	45
Code diameter (mm)	0.7	0.7	0.7	0.9	0.7	0.9	0.7	0.7
Ply gauge (mm)	1.2	1.2	1.2	1.4	1.2	1.4	1.2	1.2
Width of center cover layer (mm)	170	120	80	200	200	120	190	40
Ratio of center cover layer width (%)	85	60	40	100	100	60	95	20
Width of shoulder cover layer (mm) (one side)	15	40	60	-	-	40	5	80
Ratio of shoulder cover layer width (%) (one side)	7.5	20	30	-	-	20	2.5	40
Auxiliary fiber reinforcement layer								
Code structure	-	-	-	-	-	-	-	-
Driving density (lines / 50 mm)	-	-	-	-	-	-	-	-
Evaluation	Tire durability index	110	110	100	90	90	100	90
	Destruction form	Shoulder separation	Shoulder separation	Shoulder separation	Center cord breakage and tread separation	Shoulder separation	Shoulder separation	Center cord breakage and tread separation

[Table 1]

[0053]

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[Table 2]

	Embodiment 4	Embodiment 5	Embodiment 6	Embodiment 7	Embodiment 8	Embodiment 9	Embodiment 10	Embodiment 11		
Center cover layer										
Cord structure (yam combination)	A	A	A	A	A	A	A	A		
Total fineness (dtex)	4740	4740	4740	4740	4740	4740	4740	4740		
High modulus yarn twist count (twists/10cm)	22	25	31	34	28	28	28	28		
Low modulus yarn twist count (twists/10cm)	22	25	31	34	28	28	28	28		
Number of twists (twists/10cm)	22	25	31	34	28	28	28	28		
Upper twist factor	1515	1721	2134	2341	1928	1928	1928	1928		
Driving density (lines / 50 mm)	45	45	45	45	45	45	45	45		
Code diameter (mm)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9		
Ply gauge (mm)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4		
Shoulder cover layer										
Cord structure (yam combination)	B	B	B	B	B	B	B	B		
Total fineness (dtex)	3070	3070	3070	3070	3070	3070	3070	3070		
High modulus yarn twist count (twists/10cm)	38	38	38	38	27	30	38	41		
Low modulus yarn twist count (twists/10cm)	38	38	38	38	27	30	38	41		
Number of twists (twists/10cm)	38	38	38	38	27	30	38	41		
Upper twist factor	2105	2105	2105	2105	1496	1662	2105	2272		
Driving density (lines / 50 mm)	45	45	45	45	45	45	45	45		
Code diameter (mm)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7		
Ply gauge (mm)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2		
Width of center cover layer (mm)	120	120	120	120	120	120	120	120		
Ratio of center cover layer width (%)	60	60	60	60	60	60	60	60		
Width of shoulder cover layer (mm) (one side)	40	40	40	40	40	40	40	40		
Ratio of shoulder cover layer width (%) (one side)	20	20	20	20	20	20	20	20		
Auxiliary fiber reinforcement layer	-	-	-	-	-	-	-	-		
Code structure	-	-	-	-	-	-	-	-		
Driving density (lines / 50 mm)	-	-	-	-	-	-	-	-		
Evaluation	Tire durability index	105	130	120	110	110	110	115	130	105
	Destruction form	Center cord breakage and tread separation	Shoulder separation	Shoulder separation	Center tread peeling (no code breakage)	Center tread peeling (no code breakage)	Center tread peeling (no code breakage)	Shoulder separation	Shoulder separation	Shoulder separation

[Table 2]

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[Table 3]

	Embodiment 12	Embodiment 13	Embodiment 14	Comparative Example 6	Comparative Example 7	Comparative Example 8	Comparative Example 9	Comparative Example 10
Center cover layer								
Cord structure (yarn combination)	C	C	C	C	D	D	C	C
Total fineness (dtex)	4740	4740	4740	4740	3070	3070	4740	4740
High modulus yarn twist count (twists/10cm)	28	28	28	28	38	38	28	28
Low modulus yarn twist count (twists/10cm)	28	28	28	28	38	38	28	28
Number of twists (twists/10cm)	28	28	28	28	38	38	28	28
Upper twist factor	1928	1928	1928	1928	2105	2105	1928	1928
Driving density (lines / 50 mm)	45	45	45	45	45	45	45	45
Code diameter (mm)	0.9	0.9	0.9	0.9	0.7	0.9	0.9	0.9
Ply gauge (mm)	1.4	1.4	1.4	1.4	1.2	1.2	1.4	1.4
Shoulder cover layer								
Cord structure (yarn combination)	D	D	D	C	D	C	D	D
Total fineness (dtex)	3070	3070	3070	4740	3070	4740	3070	3070
High modulus yarn twist count (twists/10cm)	38	38	38	28	38	28	38	38
Low modulus yarn twist count (twists/10cm)	38	38	38	28	38	28	38	38
Number of twists (twists/10cm)	38	38	38	28	38	28	38	38
Upper twist factor	2105	2105	2105	1928	2105	1928	2105	2105
Driving density (lines / 50 mm)	45	45	45	45	45	45	45	45
Code diameter (mm)	0.7	0.7	0.7	0.9	0.7	0.9	0.7	0.7
Ply gauge (mm)	1.2	1.2	1.2	1.4	1.2	1.4	1.2	1.2
Width of center cover layer (mm)	170	120	80	200	200	120	190	40
Ratio of center cover layer width (%)	85	40	40	100	100	60	95	20
Width of shoulder cover layer (mm) (one side)	15	60	60	-	-	40	5	80
Ratio of shoulder cover layer width (%) (one side)	7.5	20	30	-	-	20	2.5	40
Auxiliary fiber reinforcement layer								
Code structure	-	-	-	-	-	-	-	-
Driving density (lines / 50 mm)	-	-	-	-	-	-	-	-
Evaluation	125	125	110	100	90	90	100	90
Tire durability index	Shoulder separation	Shoulder separation	Shoulder separation	Shoulder separation	Center cord breakage and tread separation	Shoulder separation	Shoulder separation	Center cord breakage and tread separation
Destruction form	Shoulder separation	Shoulder separation	Shoulder separation	Shoulder separation	Center cord breakage and tread separation	Shoulder separation	Shoulder separation	Center cord breakage and tread separation

[Table 3]

[0055]

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[Table 4]

[Table 4]

		Embodiment 15	Embodiment 16
Center cover layer			
Cord structure (yarn combination)		E	C
Total fineness (dtex)		4740	4740
High modulus yarn twist count (twists/10cm)		28	28
Low modulus yarn twist count (twists/10cm)		28	28
Number of twists (twists/10cm)		28	28
Upper twist factor		1928	1928
Driving density (lines / 50 mm)		45	45
Code diameter (mm)		0.9	0.9
Ply gauge (mm)		1.4	1.4
Shoulder cover layer			
Cord structure (yarn combination)		F	D
Total fineness (dtex)		3070	3070
High modulus yarn twist count (twists/10cm)		38	38
Low modulus yarn twist count (twists/10cm)		38	38
Number of twists (twists/10cm)		38	38
Upper twist factor		2105	2105
Driving density (lines / 50 mm)		45	45
Code diameter (mm)		0.7	0.7
Ply gauge (mm)		1.2	1.2
Width of center cover layer (mm)		120	120
Ratio of center cover layer width (%)		60	60
Width of shoulder cover layer (mm) (one side)		40	40
Ratio of shoulder cover layer width (%) (one side)		20	20
Auxiliary fiber reinforcement layer		-	
Code structure		-	g.
Driving density (lines / 50 mm)		-	45
Evaluation	Tire durability index	110	130
	Destruction form	Shoulder separation	Shoulder separation

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## [Brief Description of Drawings]

[0056]

[FIG. 1] A schematic cross-sectional view taken in the meridian direction of a pneumatic radial tire according to an embodiment of the present invention.

[FIG. 2] A schematic model diagram showing another preferred embodiment of the pneumatic radial tire of the present invention, conceptually showing the arrangement of a belt layer, an organic fiber reinforcing layer, and an auxiliary fiber reinforcing layer in a meridian cross section of the pneumatic tire as shown in FIG. 1.

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## [Reference Signs List]

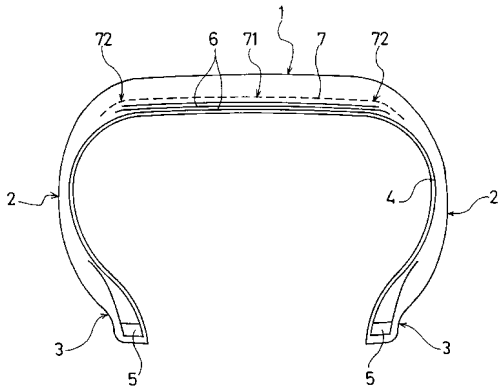
[0057]

- 1: Tread section
- 2: Side wall section
- 3: Bead section
- 4: Carcass layer
- 5: Bead core
- 6: Belt layer
- 7: Organic fiber reinforcement cover layer
- 71: Center cover layer
- 72: Shoulder cover layer

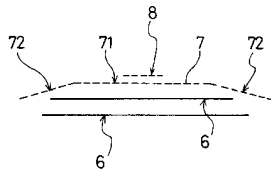
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8: Auxiliary fiber reinforcement layer

[FIG. 1]



[FIG. 2]



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Continuation of the front page

(51) Int.Cl.	FI	Theme Code (Reference)	
	B60C	9/00	D
	B60C	9/18	K