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(12) (19) (CA) **Brevet-Patent**

(11) (21) (C) **2,043,893**
(22) 1991/06/05
(43) 1991/12/16
(45) 2001/01/02


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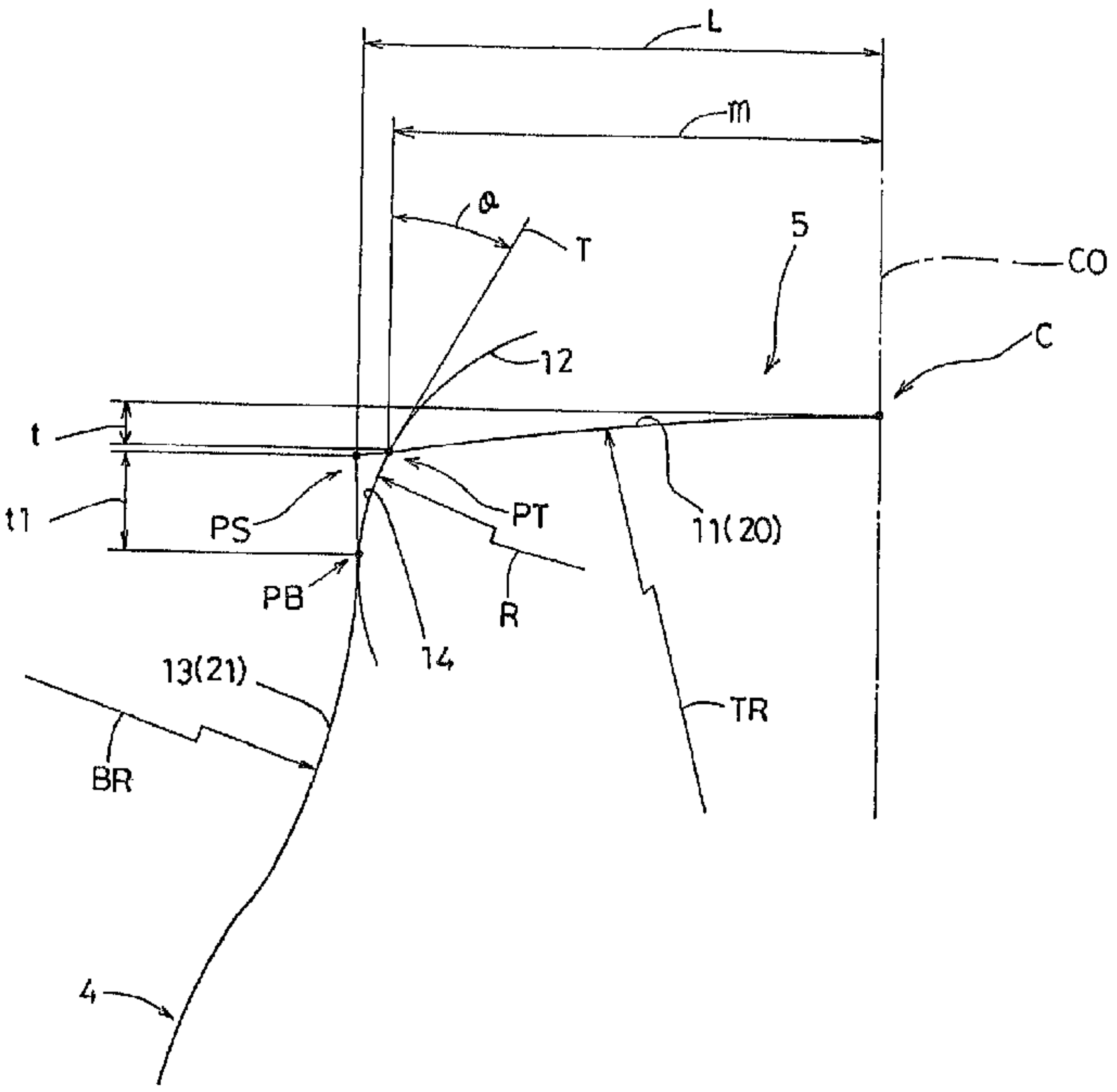
(51) Int.Cl.$^5$ B60C 5/00, B60C 11/00
(30) 1990/06/15 (2-158199) JP
(30) 1991/03/19 (3-81763) JP


(54) **PNEUMATIQUE POUR POIDS LOURDS OFFRANT UNE PLUS GRANDE RESISTANCE A L'USURE AUX EPAULES ET UNE MEILLEURE STABILITE ROUTIERE**

(54) **HEAVY DUTY TIRE WITH REDUCED SHOULDER WEAR AND IMPROVED WANDERING PERFORMANCE**





(57) A pneumatic tire is provided herein for heavy duty use. Such pneumatic tire has a profile comprising a tread profile extending between tread edges. A buttress profile extends radially-inwardly from a point on the surface of each tire sidewall. A connecting profile extends between each tread edge and the point. In a cross section including the tire axis, the tread profile is formed by an arc having an outwardly-swelling curvature of a radius, each buttress profile is formed by an arc having an inwardly-swelling curvature of a radius and each connecting profile is formed by an arc having an outwardly-swelling curvature, and intersecting the tread profile at the tread edge to form an angled corner, and which is smoothly-connected with the buttress profile at the point. The ratio of the radial distance between the tread edge and the equatorial point on the tread profile to the axial distance therebetween is 0.09 to 0.12. The ratio of the axial distance to the axial distance between the equatorial point and an imaginary point at which the tread which has the radius of curvature and the buttress arc which has the radius of curvature intersect each other if extended, is 0.85 to 0.95. The inclination angle of the tangential line to the connecting profile drawn at each tread edge is 20 to 60 degrees with respect to the radial direction of the tire. This pneumatic tire has improved shoulder wear resistance and wandering performance.

## ABSTRACT

A pneumatic tire is provided herein for heavy duty use. Such pneumatic tire has a profile comprising a tread profile extending between tread edges. A buttress profile extends radially-inwardly from a point on the surface of each tire sidewall. A connecting profile extends between each tread edge and the point. In a cross section including the tire axis, the tread profile is formed by an arc having an outwardly-swelling curvature of a radius, each buttress profile is formed by an arc having an inwardly-swelling curvature of a radius and each connecting profile is formed by an arc having an outwardly-swelling curvature, and intersecting the tread profile at the tread edge to form an angled corner, and which is smoothly-connected with the buttress profile at the point. The ratio of the radial distance between the tread edge and the equatorial point on the tread profile to the axial distance therebetween is 0.09 to 0.12. The ratio of the axial distance to the axial distance between the equatorial point and an imaginary point at which the tread which has the radius of curvature and the buttress arc which has the radius of curvature intersect each other if extended, is 0.85 to 0.95. The inclination angle of the tangential line to the connecting profile drawn at each tread edge is 20 to 60 degrees with respect to the radial direction of the tire. This pneumatic tire has improved shoulder wear resistance and wandering performance.

## (a) TITLE OF THE INVENTION

HEAVY DUTY TIRE WITH REDUCED SHOULDER WEAR AND IMPROVED WANDERING PERFORMANCE

## (b) TECHNICAL FIELD TO WHICH THE INVENTION RELATES

The present invention relates to a pneumatic tire for heavy duty use in which shoulder wear is reduced and wandering performance is improved.

## (c) BACKGROUND ART

In a tire for heavy vehicles, e.g., trucks, buses, and the like, a square shoulder in which an outwardly-swelling tread face and inwardly-swelling buttress-faces intersect at the tread edges at a right angle, has been used. Such square shoulder had the merit of an even ground pressure distribution, and thereby uneven wear became less, and the wear life of the tread was excellent.

In such tires having a square shoulder, however, the tread edges were liable to be damaged during running on a rough road. Further, the directional stability was not good. That is, wandering of the vehicle occurred during running on a road having a surface which was irregularly inclined in the lateral direction, for example, a rutted road.

The countermeasures for such problems which have been widely employed were to use a round shoulder in which the tread edge portion was rounded with an arc, or a tapered shoulder in which the tread edge portion was formed by an tapered face.

However, in tires having such round shoulder, as the ground pressure was decreased in a region near the tread edge, shoulder wear in which the tread shoulder portions were worn rapidly in comparison with the tread crown portion occurred. On the other hand, in tires having a tapered shoulder, improvement in wandering performance was not sufficient.

## (d) DESCRIPTION OF THE INVENTION

It is therefore, an object of one aspect of the present invention to provide a heavy duty tire which is improved in both wandering performance and shoulder wear performance.

According to one aspect of the present invention, a pneumatic tire for heavy duty is provided having a profile comprising a tread profile extending between tread edges, a buttress profile extending radially-inwardly from a point on the surface of each tire sidewall, and a connecting profile extending between each tread edge and that point. In a cross section including the tire axis, the following characteristics are provided: the tread profile is formed by an arc having an outwardly-swelling curvature of a radius; each buttress profile is formed by an arc having an inwardly-swelling curvature of a radius; each connecting profile is formed by an arc having an outwardly-swelling curvature, and intersecting the tread profile at the tread edge to form an angled corner which is smoothly-connected with the buttress profile at that point; the ratio of the radial distance between the tread edge and the equatorial point on the tread profile to the axial distance therebetween is 0.09 to 0.12; the ratio of the axial distance to the axial distance between the equatorial point and an imaginary point at which the tread which has the radius of curvature and the buttress arc which has the radius of curvature intersect each other if extended, is 0.85 to 0.95; and the inclination angle of the tangential line to the connecting profile drawn at each tread edge is 20 to 60 degrees with respect to the radial direction of the tire.

By one variant of this aspect of the present invention, the tire includes a further carcass having at least one ply of cords extending between a pair of bead portions and turned up around a bead core which is disposed in each of the pair of bead portions, a rubber tread, and a belt which is disposed radially-outside the carcass and inside the rubber tread.

By another variant of this aspect of the invention, and the above variant, at least one carcass ply is composed of steel cords which are arranged radially at an angle of 70 to 90 degrees with respect to the tire equator, and the belt is composed of four plies of steel cords and has a triangulated cord structure.

By yet another variant of this aspect of the invention, and the above variants thereof, the tire further includes a pair of wedge-shaped cushions, each of the pair of cushions being made of rubber, the belt has a central major part and a pair of edge parts, the major part directly contacting with the carcass, and one of the pair of cushions is disposed between each of the edge parts and the carcass so as to provide a distance therebetween which increases gradually toward the axially-outside of the tire.

## (e) DESCRIPTION OF THE FIGURES

In the accompanying drawings:

FIG. 1 is a sectional view showing an embodiment of one aspect of the present invention;

FIG. 2 is a diagram showing the profile thereof;

FIG. 3 is a developed plan view showing the tread pattern thereof; and

FIGS. 4-6 are schematic sectional views each showing prior art.

## (f) DESCRIPTION OF THE PRIOR ART

FIGS. 4-6 are schematic sectional views each showing embodiments of the prior art.

In a tire for heavy vehicles, e.g., trucks, buses and the like, a square shoulder in which, as shown in FIG. 4, an outwardly-swelling tread face (a) and inwardly-swelling buttress faces (b) intersect at the tread edges at about a right angle, has been used. Such square shoulder has the merit of an even ground pressure distribution, and thereby uneven wear becomes less, and the wear life of the tread is excellent.

In such tires having the square shoulder, however, the tread edges are liable to be damaged during running on the rough road, and further the directional stability is not good. That is, wandering of the vehicle is occurred during running on a road having a surface irregularly inclined in the lateral direction, for example, a rutted road.

The countermeasures for such problems which have been widely employed are to use either a round shoulder in which the tread edge portion (c) is rounded with an arc

(R) as shown in FIG. 5, or a tapered shoulder in which the tread edge portion is formed by a tapered face (e) as shown in FIG. 6.

## (g) AT LEAST ONE MODE FOR CARRYING OUT THE INVENTION

FIG. 1 shows heavy duty tire 1, which is a truck/bus radial tire having a typical size of 10.00R20-14PR, and which is in its normal inflated state in which the tire is mounted on its regular rim of size 7.50VX20 and inflated to its maximum inner pressure.

The tire 1 has a tread portion 5, a pair of axially-spaced bead portions 3 and a pair of sidewall portions 4 extending therebetween.

The tire 1 comprises a pair of bead cores 2 which is disposed one in each bead portion, a carcass 6 having at least one ply of cords extending between the bead portions and turned up around the bead cores from the axially inside to the outside thereof, a stiff belt 7 which is disposed radially-outside the carcass and inside a rubber tread, and a bead apex 9 which is disposed in each bead portion and between the carcass ply turned-up portion and main portion.

In this embodiment of one aspect of this invention, the carcass is composed of one ply 6A of cords which is arranged radially at an angle of 70 to 90 degrees with respect to the tire equator CO.

For the carcass cords, steel cords are used, but organic fibre cords, e.g. nylon, polyester, rayon, aromatic polyamide and the like and inorganic fibre cords may alternatively be used.

The belt 7 in this embodiment of one aspect of this invention is composed of first to fourth plies 7A, 7B, 7C and 7D which are arranged in this order from the radially-inner carcass side to outer side. The radially-innermost first belt ply 7A is composed of steel cords which are laid at an angle of 40 to 70 degree with respect to the tire equator CO, and the second to fourth belt plies 7B-7D are each composed of steel cords which are laid at an angle of 10 to 30 degrees with respect to the tire equator. With regard to the cord inclinations based on the tire equator, in order to provide a stiff triangle structure for the belt, the first ply 7A and the second ply 7B are inclined in the same direction, but the second ply 7B is inclined in a direction opposite to that of the third ply

7C to cross each other. Further the third ply 7C and fourth ply 7D are inclined in the same direction.

The belt 7 is disposed on the radially-outside of the carcass, and the major part of the belt or the inner most ply comes into direct contact with the carcass. Between each of the edge portions thereof and the carcass, a wedge-shaped breaker cushion 10, which is made of soft rubber, is disposed so as to provide a distance which increases gradually toward the axially-outside of the tire. Further, in order effectively to disperse and mitigate the share stress liable to concentrate on a region between the breaker cushion and the belt edge portion, the ply edges are shifted such that the second ply 7B is widest, and the first ply 7A has almost the same width as the third ply 7C but slightly narrower, and the radially-outermost fourth ply 7D is narrowest. Furthermore, between each edge portion of the third ply 7C and the second ply 7B, a wedge-shaped rubber strip is disposed to provide a gradually-increasing distance therebetween as shown in FIG. 1.

In broad aspects of the present invention effectively to improve wandering performance and shoulder wear resistance, the profile of the tire is specifically-defined as shown in FIG. 2, which shows a cross-section of the tire including the tire axis.

The tire profile comprises a tread profile 11 extending between the tread edges PT, a buttress profile 13 extending radially-inwardly from a point PB on each tire sidewall, and a connecting profile 14 extending between the point PB and each tread edge PT.

The tread profile 1 is formed by an arc 20 having a single radius of curvature TR. The centre thereof is positioned on the equatorial plane of the tire so that the tread profile swells radially-outwardly of the tire.

The buttress profile 13 is formed by an arc 21 having a single radius of curvature BR. The centre thereof is positioned axially-outward of the sidewall so that the profile swells inwardly of the tire.

The connecting profile 14 is formed by an arc 12 having a single radius of curvature R. The centre thereof is positioned axially-inward of the sidewall so as to swell outwardly of the tire.

The connecting profile 14 is smoothly joined to the buttress profile 13 at the above-mentioned point PB. Therefore, the point PB is a point of inflection between the arcs 12 and 13. On the contrary, the connecting profile 14 intersects the tread profile 11 at the tread edge PT at an angle which is narrower than a straight angle which is wider than a right angle so as to form an angled corner.

A tangential line T to the connecting profile 14 which is drawn at the tread edge PT to extend radially-outwardly is inclined axially-inwardly at an angle $\theta$ of 20 to 60 degrees with respect to the radial direction, whereby the tread edges are prevented form being torn off. When the angle $\theta$ is less than 20 degrees, the angle of the tread edge becomes too narrow, and the tread edge is liable to be torn off. When the angle $\theta$ is more than 60 degrees, a region of the connecting profile 14 near the tread edge contacts the ground, and shoulder wear start therefrom.

Further, the tread camber which is defined by the ratio t/m of the radial distance t between the tread edge PT and the central point C on the tread profile at the tire equator to the axial distance m therebetween is set in the range of 0.09 to 0.12. When the ratio t/m is less than 0.09, the ground pressure becomes large in the tread shoulder regions in comparison with the tread central region, and shoulder wear is caused. On the contrary, when the ratio t/m is more than 0.12, the ground pressure becomes large in the central region, and the central region wears rapidly.

As the connecting profile is formed by the outwardly-swelling arc 12, it becomes easy to run over protrusions on the road surface, e.g., ruts, rails and the like, and the shock when such running over can be softened.

As the tread edge PT is angled and the t/m ratio is 0.09 to 0.12, the ground pressure distribution becomes even, and uneven wear, e.g., shoulder wear of the tread can be reduced.

Furthermore, the ratio m/L of the axial distance m between the tread edge PT and the central point C to the axial distance L between the central point C and an imaginary point PS at which the arc of the radius TR and the arc of the radius BR intersect each other if extended, is set in the range of 0.85 to 0.95. The connecting face 14 is thus allowed to have a width t1 and a curvature R which are appropriate for a smooth running over a protrusion in a well-balanced manner. When the ratio m/L is less than 0.85, the resultant increased radius R impairs the running-over performance. Further the ground-contacting width is excessively decreased to deteriorate running performance. When the ratio m/L is more than 0.95, the width t1 is excessively decreased and an effective improvement in the running-over performance is not obtained.

FIG. 3 shows a tread pattern which is suitable for the tire according to one aspect of the present invention.

The tread is provided with four circumferentially-extending main grooves G to divide the tread into five ribs: one central rib 16A; two middle ribs 16B; and two shoulder ribs 16C. The central rib 16A and the shoulder ribs 16C are provided with zigzag sipes 17 extending across the whole width of the respective ribs. The middle ribs 16B are provided with zigzag grooves 18 having substantially the same shape as the sipes 17 but having a wider groove width. The grooves 18 extend across the whole width of the respective ribs to divide the ribs into circumferentially separated blocks. Further, to adjust the rigidity of the tread edge, the tread edge is provided with sipes or cuts 19 extending in the axial direction of the tire from the tread face 11 to the connecting face 14.

The present invention in its various aspects can be applied to semiradial tires and bias tires in addition to radial tires.

Test tires of size 10.00R20 having specifications given in Table 1 were prepared and tested for wandering performance, shoulder wear resistance, tread life and tread edge durability. The test results are also shown in Table 1.

In the wandering performance test, test tires were installed on the front wheels of a test vehicle, and the resultant wandering of the vehicle when running into and out of a rut formed on a rough road and the required handle operation are evaluated into four ranks A-D as the wandering performance by the driver's feeling. (A: excellent, B: good, C: passable, D: bad)

In the shoulder wear test, the test tire was run on a well paved road at a constant speed under the maximum tire load specified in JIS, and the amount of the tread wear was measured at the tread shoulders when the depth of the remaining main grooves reached to 10 mm. (A:small, B:middle, C:large)

In the tread life test, the above-mentioned constant-speed running was continued, and the total running distance until it became necessary to change the test tire to a new tire due to its shoulder wear was measured. The measurements are indicated by an index based on the assumption that prior art tire 2 is 100. The larger the index, the longer the life.

In the edge durability test, when the tire reached the end of tread life in the former test, the tread edges were inspected to find whether the edges were torn off. (A:non, B:small, C:large)

TABLE 1

| | Ex.1 | Ex.2 | Ex.3 | Ref.1 | Ref.2 | Prior 1 | Prior 2 | Prior 3 |
|---|---|---|---|---|---|---|---|---|
| Plofile | Fig.1 | Fig.1 | Fig.1 | Fig.1 | Fig.1 | Fig.4 | Fig.5 | Fig.6 |
| TR | 450 | 450 | 450 | 450 | 450 | 680 | 575 | 450 |
| BR | 150 | 150 | 150 | 150 | 150 | 120 | 120 | 120 |
| R | 20 | 36 | 30 | 85 | 20 | --- | 10 | --- |
| θ (deg) | 20 | 60 | 48 | 15 | 65 | --- | --- | 35 |
| L (mm) | 102 | 102 | 102 | 102 | 102 | 99 | 102.5 | 102 |
| m (mm) | 97 | 87 | 92 | 97 | 97 | 99 | 97.5 | 92 |
| t (mm) | 11.7 | 8.5 | 9.2 | 11.7 | 11.7 | 7.25 | 9.2 | 5 |
| t/m | 0.11 | 0.12 | 0.09 | 0.11 | 0.11 | 0.07 | 0.09 | 0.05 |
| m/L | 0.95 | 0.85 | 0.90 | 0.80 | 0.97 | 1.0 | 0.95 | 0.90 |
| Wandering | B | B | A | D | A | D | B | C |
| Shoulder wear | A | A | A | A | C | A | C | B |
| Tread life | 123 | 118 | 136 | 91 | 82 | 100 | 82 | 90 |
| Tread edge tear | A | A | A | B | A | C | A | A |

CLAIMS

1. A pneumatic tire for heavy duty having a profile comprising:

a tread profile extending between tread edges;

a buttress profile extending radially-inwardly from a point on the surface of each tire sidewall; and

a connecting profile extending between each tread edge and said point;

wherein, in a cross section including the tire axis:

said tread profile is formed by an arc having an outwardly-swelling curvature of a radius;

each buttress profile is formed by an arc having an inwardly-swelling curvature of a radius;

each connecting profile is formed by an arc having an outwardly-swelling curvature and intersecting said tread profile at the tread edge to form an angled corner which is smoothly-connected with said buttress profile at the point;

the ratio of the radial distance between the tread edge and the equatorial point on the tread profile to the axial distance therebetween is 0.09 to 0.12;

the ratio of said axial distance to the axial distance between said equatorial point and an imaginary point at which said tread, which has the radius of curvature, and the buttress arc, which has the radius of curvature, intersect each other if extended, is 0.85 to 0.95; and

the inclination angle of the tangential line to the connecting profile drawn at each said tread edge is 20 to 60 degrees with respect to the radial direction of said tire.

2. The tire according to claim 1, wherein said tire also comprises: a further carcass having at least one ply of cords extending between a pair of bead portions and turned-up around a bead core which is disposed in each of said pair of bead portions; a rubber tread; and a belt which is disposed radially-outside said carcass and inside said rubber tread.

3. The tire according to claim 1 or claim 2, wherein said at least one carcass ply is composed of steel cords which are arranged radially at an angle of 70 to 90 degrees with

respect to the equator of the tire, and wherein said belt is composed of four plies of steel cords and has a triangulated cord structure.

4. The tire according to claim 1, claim 2 or claim 3, further comprising: a pair of wedge-shaped cushions, each of said pair of cushions being made of rubber; said belt having a central major part and a pair of edge parts, said major part directly contacting with said carcass, and one of said pair of cushions being disposed between each of said edge parts and said carcass so as to provide a distance therebetween which increases gradually toward the axially-outside of the tire.

Fig. 1

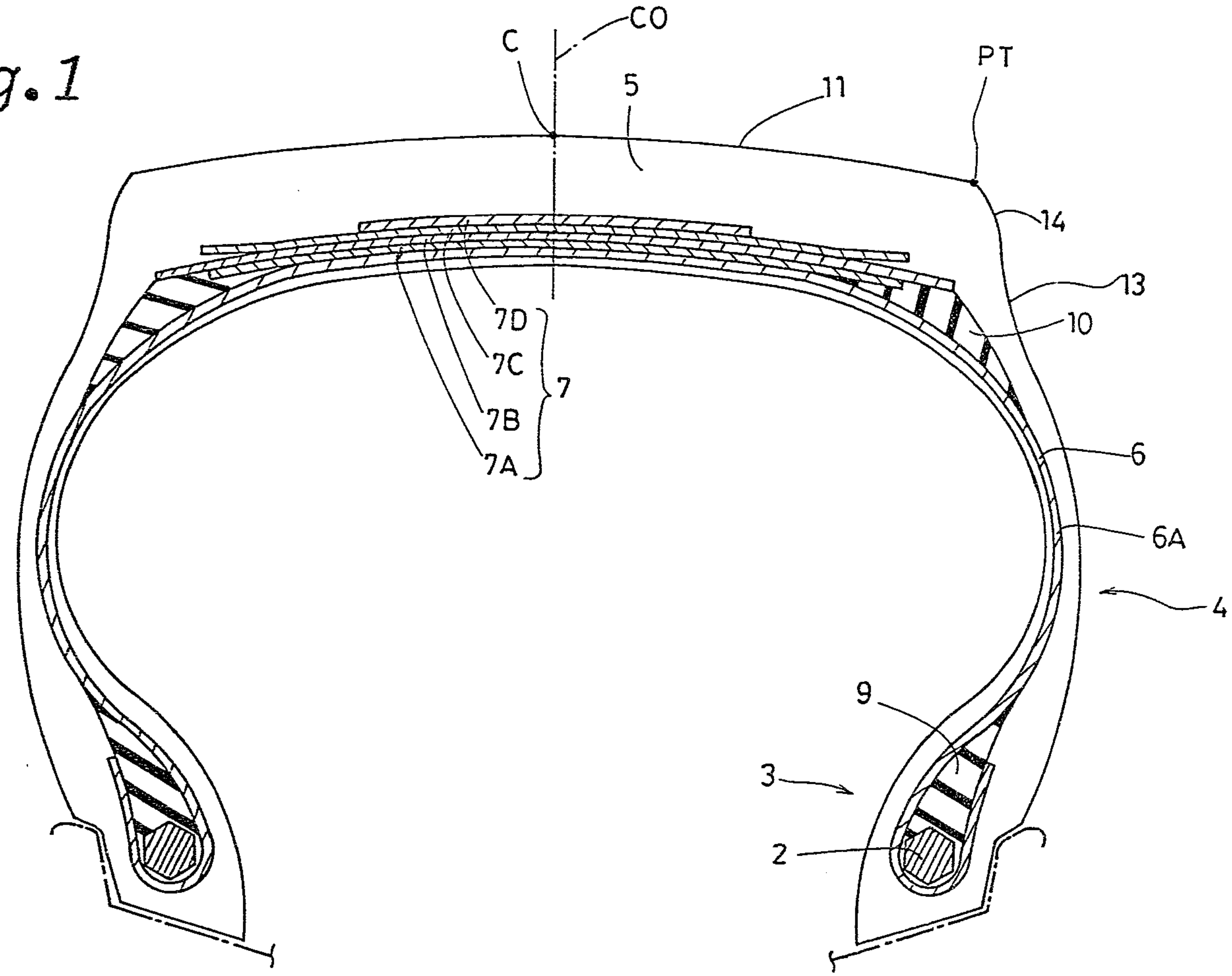



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Fig. 2

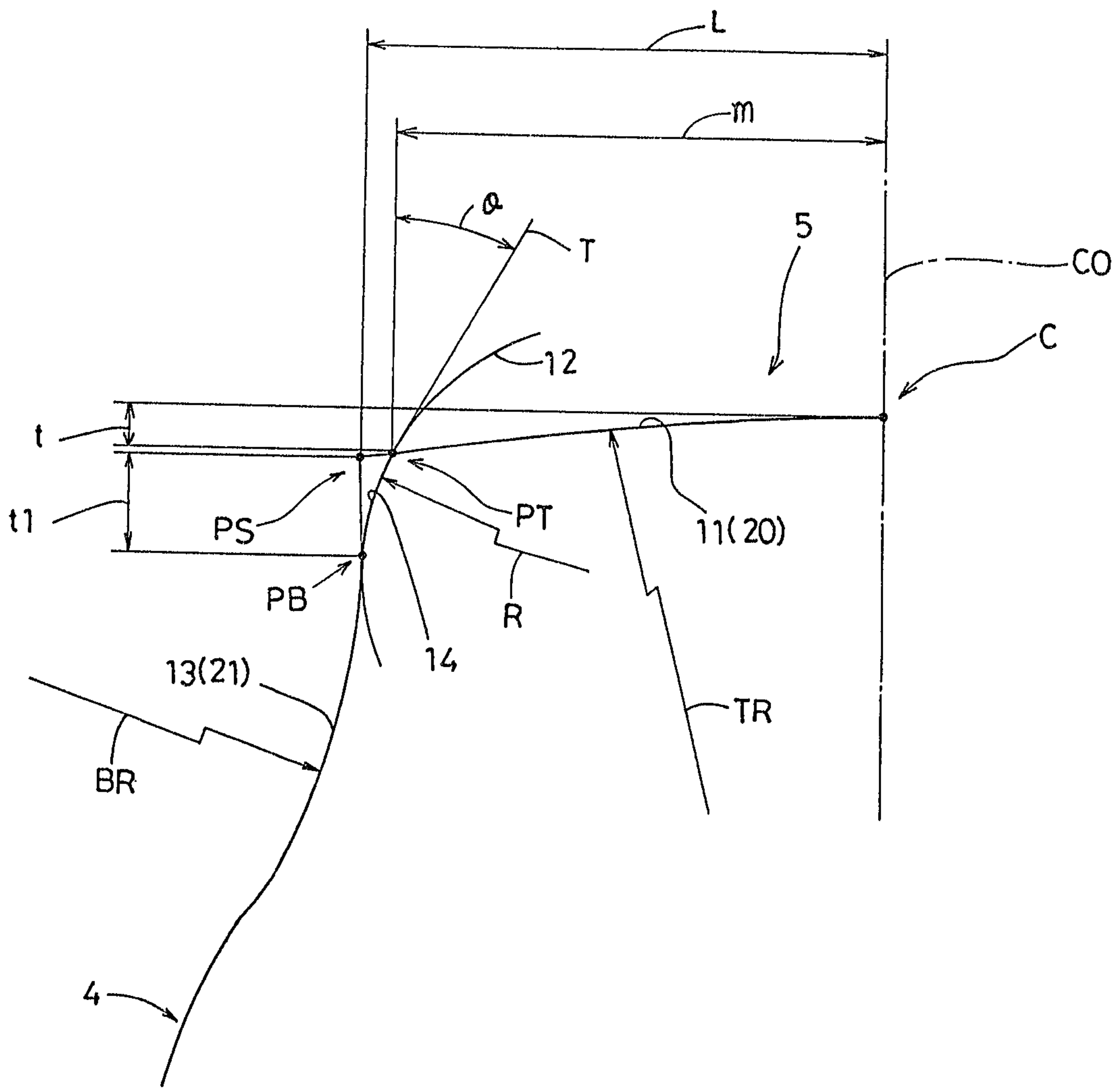


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Fig.3

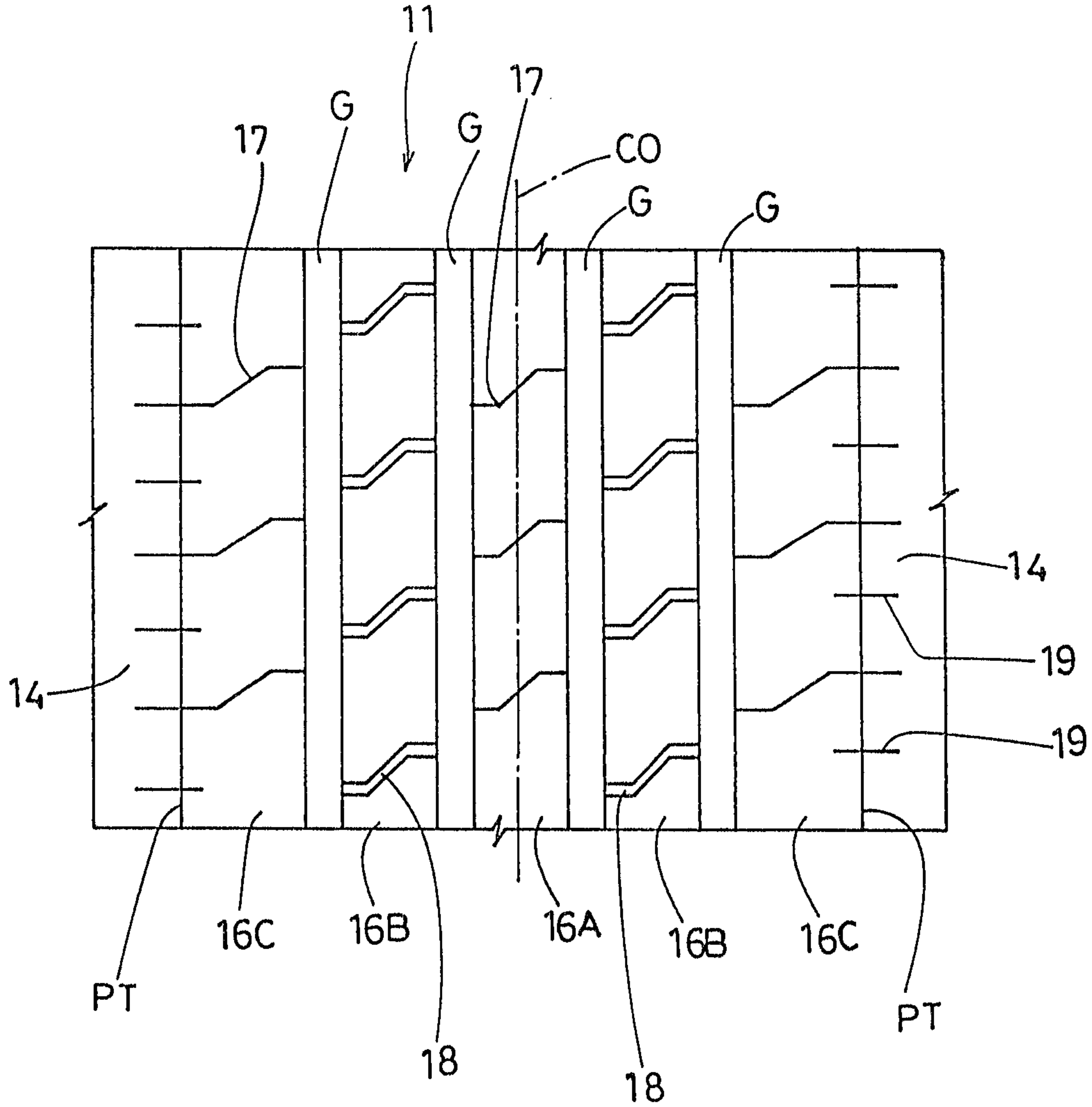


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Fig. 4

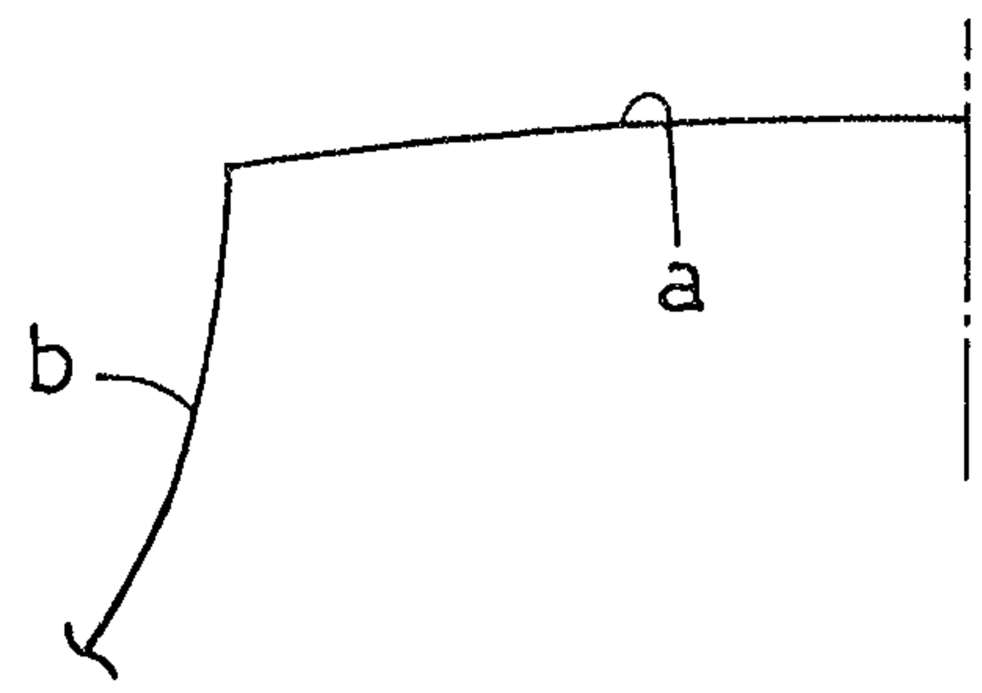


Fig. 5

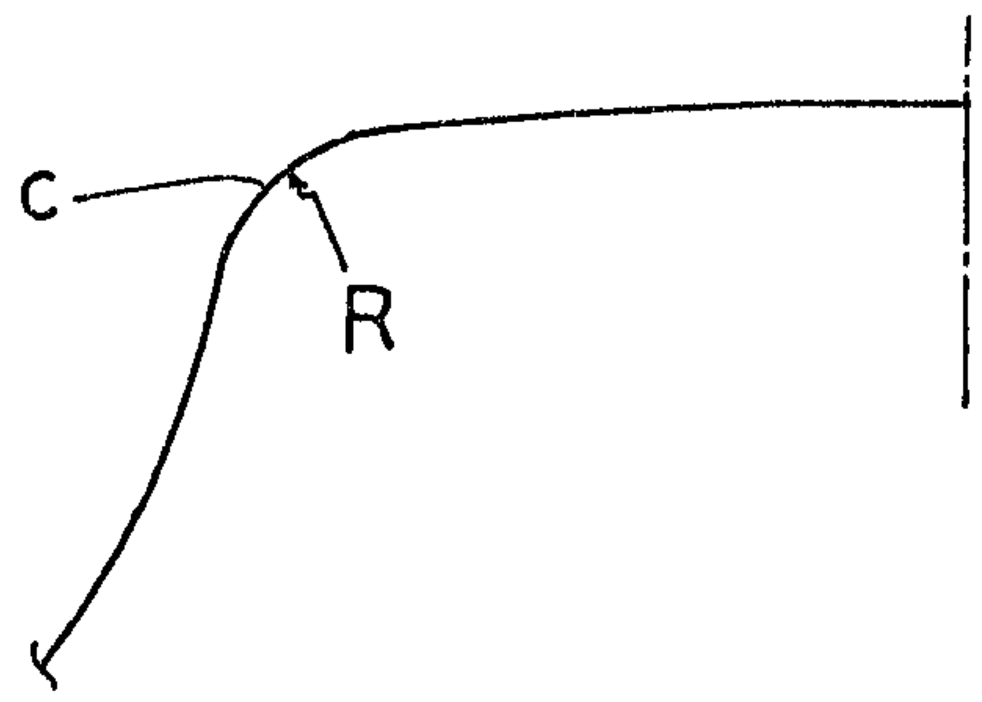


Fig. 6


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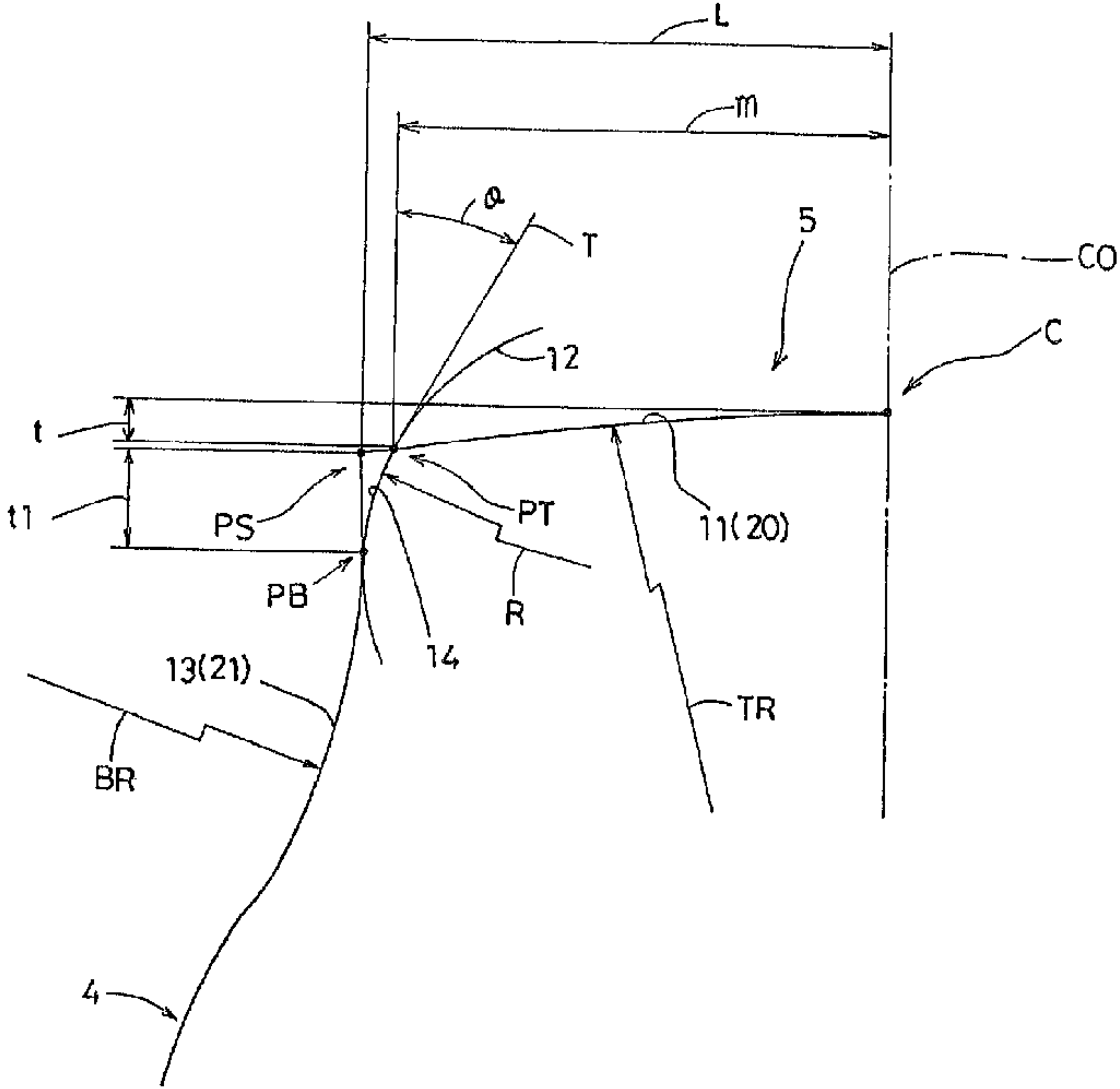

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T
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CO
C
12
t
t1
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11(20)
PB
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13(21)
TR
BR
4