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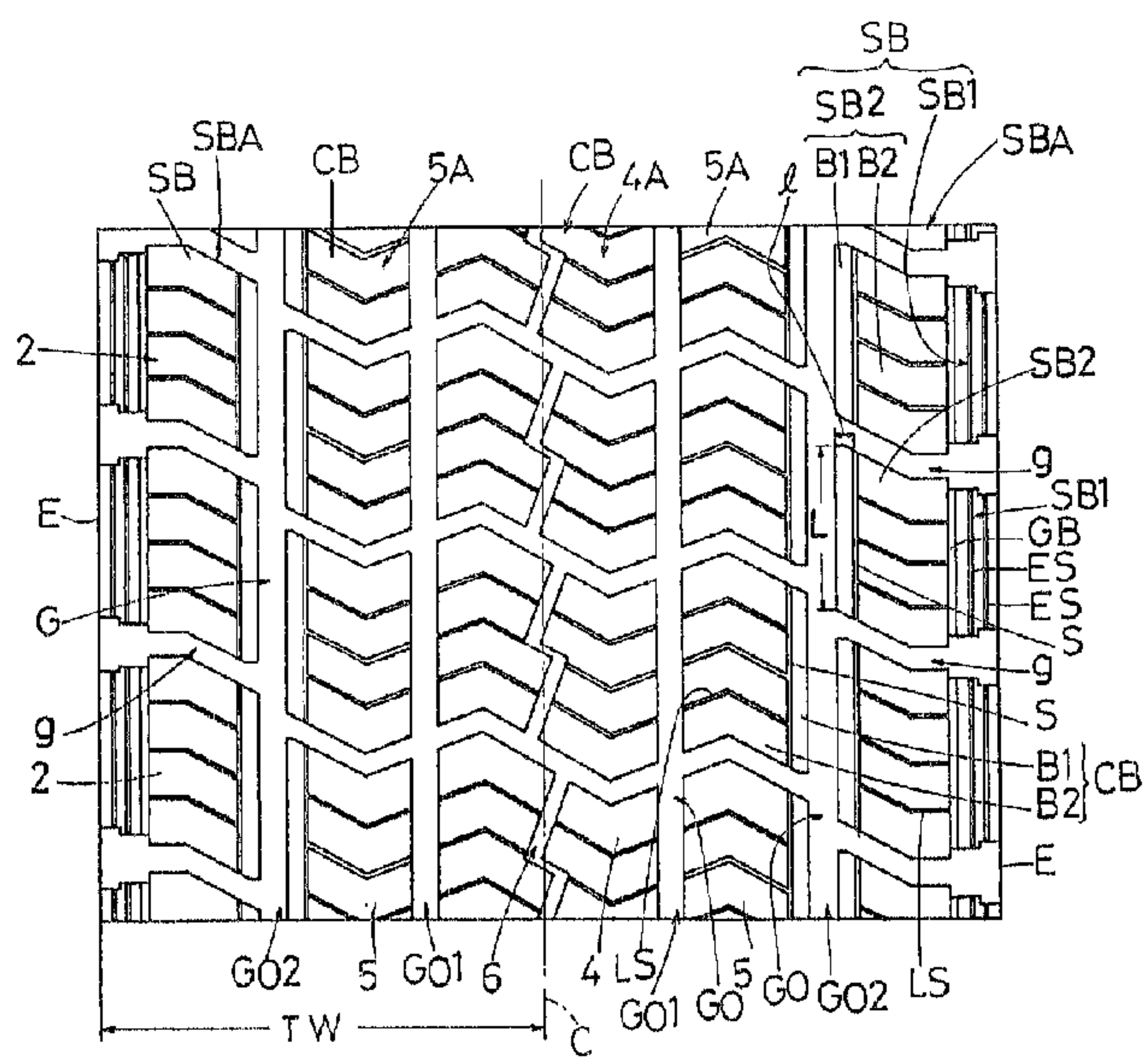

(57) Abrégé/Abstract:
A pneumatic tire is provided herein comprising a tread portion having a pair of tread edges. The tread portion is provided with at least two main circumferential grooves and with axial grooves to define tread blocks which are arranged in two or more circumferential rows. The tread blocks comprise shoulder blocks which are between each axially-outermost main circumferential groove and each tread edge. Each of the shoulder blocks is provided with a narrow circumferential shoulder groove so as to subdivide the block axially into an axially-outer shoulder block part and an axially-inner shoulder block part. The axial width of the axially-outer shoulder block part, measured from the tread edge to the narrow circumferential shoulder groove is 0.06 to 0.25 times the tread half-width between one tread edge to a tire equator. The mean groove depth of the narrow circumferential shoulder groove is 0.3 to 1.10 times the groove depth of the main circumferential grooves. Each of the tread blocks in the two or more circumferential rows is provided with one or more sipes extending circumferentially of the tire to divide the tread block into two or more axial parts. The sipe or sipes have a width of 0.2 to 1.5 mm. The sipe or sipes are disposed in the axially-outer shoulder block part. The mean depth of each of the sipe or spies is 0.25 to 1.25 times the mean groove depth of the narrow circumferential shoulder groove.

ABSTRACT

A pneumatic tire is provided herein comprising a tread portion having a pair of tread edges. The tread portion is provided with at least two main circumferential grooves and with axial grooves to define tread blocks which are arranged in two or more circumferential rows. The tread blocks comprise shoulder blocks which are between each axially-outermost main circumferential groove and each tread edge. Each of the shoulder blocks is provided with a narrow circumferential shoulder groove so as to subdivide the block axially into an axially-outer shoulder block part and an axially-inner shoulder block part. The axial width of the axially-outer shoulder block part, measured from the tread edge to the narrow circumferential shoulder groove is 0.06 to 0.25 times the tread half-width between one tread edge to a tire equator. The mean groove depth of the narrow circumferential shoulder groove is 0.3 to 1.10 times the groove depth of the main circumferential grooves. Each of the tread blocks in the two or more circumferential rows is provided with one or more sipes extending circumferentially of the tire to divide the tread block into two or more axial parts. The sipe or sipes have a width of 0.2 to 1.5 mm. The sipe or sipes are disposed in the axially-outer shoulder block part. The mean depth of each of the sipe or spies is 0.25 to 1.25 times the mean groove depth of the narrow circumferential shoulder groove.

PNEUMATIC TIRE

TECHNICAL FIELD

The present invention relates to a pneumatic tire having an improved tread pattern capable of improving road grip without sacrificing wear resistance or tread durability.

BACKGROUND ART

Recently, in order to prevent dust pollution, studless tires for use on snowy and icy roads are being brought into greater use for heavy duty vehicles, e.g., trucks and busses, instead of spiked tires.

In studless tires, block tread patterns are widely used to obtain a large traction and a large braking force. In general, in order to improve traction and braking force, the tread blocks are provided with axially-extending sipes so as to divide each block into comparatively-narrow tread elements having free axial ends which are located at a main circumferential groove and/or the tread edge. The resultant narrow tread elements are easily moved during running, and uneven wear is liable to occur along the edges thereof. Since the movement is very large at the free ends, the wear is very large at the free ends, and the ends are liable to be torn off.

On the other hand, such axial sipes cannot improve resistance to lateral skid during cornering and also cannot prevent unexpected lateral movement of the vehicle on a slippery road surface when braked or started.

In Japanese published patent application No. 2-333756, a pneumatic tire is disclosed, wherein, in order to prevent lateral skid and wandering of the vehicle during running on well paved roads which have shallow ruts, the tread is provided between each shoulder block and a tread edge with at least two circumferentially-extending narrow blocks. Those blocks are divided by circumferentially-extending grooves having a width of 2.0 mm to 4.5 mm. As the widths of the blocks are small and the widths of the grooves are rather large, the tread shoulder is decreased in lateral rigidity, and thereby wandering is effectively prevented.

However, as the narrow blocks are easily moved and the movement is very large due to the large groove width, the narrow block edges cannot effectively grip the road surface. Further, the narrow blocks wear rapidly to produce uneven wear. Furthermore, the narrow blocks are liable to be torn off.

DESCRIPTION OF THE INVENTION

It is therefore an object of a main aspect of the present invention to provide a pneumatic tire, in which, by using circumferentially-extending sipes and then specifically defining their positions and sizes, e.g., width, depth and the like, lateral skid on snowy/icy roads is improved without sacrificing resistance to uneven wear, tread durability, and/or resistance to tear-off.

According to a first aspect of the present invention, a pneumatic tire is provided comprising a tread portion having a pair of tread edges. The tread portion is provided with at least two main circumferential grooves and with axial grooves to define tread blocks which are arranged in at least two circumferential rows. The tread blocks comprise shoulder blocks which are between each axially-outermost main circumferential groove and each tread edge. Each of the shoulder blocks is provided with a narrow circumferential shoulder groove so as to subdivide the block axially into an axially-outer shoulder block part and an axially-inner shoulder block part. The axial width of the axially-outer shoulder block part, measured from the tread edge to the narrow circumferential shoulder groove is 0.06 to 0.25 times the tread half-width between one tread edge to a tire equator. The mean groove depth of the narrow circumferential shoulder groove is 0.3 to 1.10 times the groove depth of the main circumferential grooves. Each of the tread blocks in the at least two circumferential rows is provided with at least one sipe extending circumferentially of the tire to divide the tread block into at least two axial parts. The at least one sipe has a width of 0.2 to 1.5 mm. The at least one sipe is disposed in the axially-outer shoulder block part. The mean depth of each of the at least one sipe is 0.25 to 1.25 times the mean groove depth of the narrow circumferential shoulder groove.

By a first variant of this first aspect of the present invention, the main circumferential grooves are two main circumferential grooves which are arranged at symmetrical axial positions with respect to the tire equator, each of the two main circumferential grooves defining a circumferential row of the tread blocks which is located adjacent to the groove and on one side of the groove. Each of the tread blocks is provided with a sipe extending continuously in substantially-parallel with the main circumferential groove so as to divide the tread block into a wide main region and a narrow lateral region on the main circumferential groove side, the circumferential length of the narrow lateral region being more than 3.0 times but less than 20.0 times the groove width of the main circumferential grooves. The mean depth of each of the at least one sipe is 0.25 to 1.0 times the groove depth of the main circumferential grooves. The groove depth of the axial grooves is more than 0.40 times but not more than 1.0 times the groove depth of the main circumferential grooves. By a variation thereof, the wide main region is provided with a plurality of circumferentially-spaced, axially-extending, axial sipes.

By a second variant of this first aspect of the present invention, and/or the above variant thereof, the main circumferential grooves are straight grooves, and the axial grooves are bent grooves.

A second broad aspect of the present invention provides a pneumatic tire comprising a tread portion having a pair of tread edges. The tread portion is provided with two wide main circumferential grooves and with axial grooves extending between the wide main circumferential grooves and the tread edges so as to define tread shoulder blocks in two circumferential rows. Each of the shoulder blocks is provided with a narrow, circumferential shoulder groove so as to subdivide the block axially into an axially-outer shoulder block part, and an axially-inner shoulder block part, the groove width of the narrow circumferential shoulder groove being smaller than that of the wide main circumferential grooves, and being in the range of from 1.5 to 2.5 mm. The mean groove depth of the narrow circumferential shoulder groove is 0.3 to 1.10 times the groove depth of the wide main circumferential grooves, and the axial width of the axially-outer shoulder block part, measured from the tread edge to the narrow circumferential shoulder groove is 0.06 to 0.25 times the tread half-width between one tread edge to a tire equator. The axially-outer shoulder block part is provided with an edge sipe extending circumferentially of the tire. The axially-inner shoulder block part is provided with a groove-side sipe extending continuously in substantially-parallel with the main circumferential groove so as to divide the inner part into a wide main region and a narrow lateral region on the main circumferential groove side. The edge sipe and the groove-side sipe have widths which are smaller than that of the narrow circumferential shoulder groove and which are in the range of 0.2 to 1.5 mm. The narrow lateral region has a circumferential length which is more than 3.0 times but less than 20.0 times the groove width of the main circumferential grooves and has an axial width which is 0.06 to 0.25 times the tread half-width. The wide main region is provided with circumferentially-spaced, axial sipes extending axially from the narrow circumferential shoulder groove to the groove-side sipe.

By a variant of this second broad aspect of the present invention, the main circumferential grooves are straight grooves extending in parallel with the tire equator, the axial grooves are bent grooves, the groove-side sipes and the edge sipes are straight sipes extending in parallel with the tire equator, and the axial sipes are bent so as to extend in parallel with the axial grooves.

DESCRIPTION OF THE FIGURES

In the accompanying drawings:

Fig. 1 is a developed plan view of the tread portion of a studless truck/bus tire according to an embodiment of an aspect of the present invention;

Fig. 2 is a cross-sectional view of the tire;

Fig. 3 is an enlarged perspective view showing a tread shoulder part thereof;

Fig. 4 is a plan view showing a modification of the tread pattern;

Figs. 5 to 9 are graphs showing test results; and

Fig. 10 is a perspective view showing a tread shoulder part according to the prior art.

Before describing the present invention, Applicant would like to describe the prior art, e.g., published Japanese Patent Application No. 2-333756, especially as shown in Fig. 10. As shown in that drawing, a pneumatic tire is disclosed, wherein, in order to prevent lateral skid and wandering of the vehicle during running on well paved roads but which have shallow ruts, the tread is provided, between each shoulder block (a) and a tread edge (e), with at least two circumferentially-extending narrow blocks (b). Those blocks (a,b) are divided by circumferentially-extending grooves (g) having a width of 2.0 mm to 4.5 mm.

As the widths of the blocks (b) are small and the widths of the grooves are rather large, the tread shoulder is decreased in lateral rigidity, and thereby wandering is effectively prevented.

However, as the narrow blocks (b) are easily moved and the movement is very large due to the large groove width, the narrow block edges cannot effectively grip the road surface. Further, the narrow blocks (b) wear rapidly to produce uneven wear. Furthermore, the narrow blocks (b) are liable to be torn off.

AT LEAST ONE MODE FOR CARRYING OUT THE INVENTION

In Figs. 1 to 3, pneumatic tire 1 comprises a tread portion 12 having a tread face 2 having a pair of edges E, a pair of axially-spaced bead portions 14, a pair of sidewall portions 13 extending between the tread edges E and the bead portions 14, a bead core 15 disposed in each bead portion 14, a toroidal carcass 16 extending between the bead portions 14 and turned up around the bead cores 15, and a belt 19 disposed radially outside the carcass 16 and inside the tread portion 12.

The carcass 16 comprises at least one carcass ply of a radial or semi-radial structure. In this embodiment, the carcass cords are arranged radially at 70 to 90 degrees with respect to the tire equator C.

For the carcass cords, steel cords and organic fiber cords, e.g. nylon, polyester, rayon, aromatic polyamide and the like can be used.

The belt 19 comprises two or more cross plies in which the belt cords are laid in parallel with each other but crosswise to the cords in the next ply. In this embodiment, the belt 19 is composed of three cross plies.

For the belt cords, steel cords and organic fiber cords, e.g. nylon, polyester, rayon, aromatic polyamide and the like can be used.

The above-mentioned tread portion 12 is provided in the tread face 2 with wide main circumferential grooves GO extending continuously around the tire.

In this example, the main circumferential grooves GO include a central zigzag groove 6 located at the tire equator C, two axially outermost straight grooves GO2 located one on each side the tire equator, and two middle straight grooves GO1 each located between the grooves 6 and GO2, thereby dividing the tread portion into six axial portions.

The six axial portions are circumferentially divided by axial grooves (g) extending from the tread edges E to the

axially outermost main circumferential grooves GO2, and axial grooves extending between the adjacent wide main circumferential grooves GO.
Accordingly, the tread pattern in this embodiment is a block pattern consisting of blocks B arranged in six circumferential rows.

The above-mentioned paired grooves GO2 and GO2 are located at symmetrical axial positions with respect to the tire equator C, and also the paired grooves GO1 and GO1 are located at symmetrical axial positions.

Each of the axial grooves inclusive of the axially outermost grooves (g) are bent in the middle thereof.
The axial grooves are arranged in such a way that, in the axial direction of the tire, the grooves are generally regarded as extending continuously from one tread edge E to the other tread edge E in a zigzag form.
All the resultant zigzag grooves extending across the whole tread width are in parallel each other and inclined toward one direction (in Fig.1, a left side upward inclination.)
In this embodiment, however, on both sides of each of the axially outermost circumferental grooves GO2, the axial grooves are slightly shifted in the circumferntial direction of the tire as shown in Fig.1.

Accordingly, between each outermost circumferential groove GO2 and the adjacent tread edge E, a row SBA of shoulder blocks SB is formed.

Further, between each middle circumferential groove GO1 and the adjacent outermost circumferential groove GO2, a row 5A of middle tread blocks 5 is formed.

Furthermore, between the middle circumferential grooves GO1 and GO1, a row 4A of central tread blocks 4 is formed on each side of the tire equator C.

In the embodiment, as the shoulder blocks SB are defined by the straight circumferential groove GO2, the tread edge E, and the bent axial grooves (g), each shoulder block SB has two straight side edges and two bent front/rear edges.

The circumferential pitches of the axial grooves (g) are such that the circumferential length L of the shoulder blocks measured along the axially inner side edge is 3.0 to 20.0 times the groove width GW of the adjacent main circumferential groove G, or the outermost main circumferential groove GO2.

The groove depth gH of the axial grooves is preferably more than 0.40 times and not more than 1.0 times the groove depth GH of the wide main circumferential grooves GO.

Each of the shoulder blocks SB is axially subdivided by a narrow circumferential shoulder groove GB into an axially outer shoulder block part SB1 and an axially inner shoulder block part SB2.

The narrow circumferential shoulder groove GB is a straight groove extending parallel with the tread edge E from the front edge to the rear edge of the shoulder block SB, and located such that the axial width WSB1 of the axially outer shoulder block part SB1 is 0.06 to 0.25 times the tread half-width TW between the tire equator C and one tread edge E.

In this embodiment, the width WSB1 is constant in the circumferential direction of the tire, but it may be varied.

If the width WSB1 is less than 0.06 times the tread half-width TW, the axial rigidity of the axially outer shoulder block part SB1 decreases and uneven wear is liable to occur.
If the width WSB1 is more than 0.25 times TW, the rigidity increases which lowers the sipe edge effect of the axially outer shoulder block part. As a result, lateral skid and wandering are liable to occur.

The groove width of the narrow circumferential shoulder groove GB is in the range of 1.5 to 2.5 mm. In this example, the width is constant in the circumferential direction of the tire and in its depthwise direction.

The mean groove depth BH of the narrow circumferential shoulder groove GB is 0.3 to 1.10 times the groove depth GH of the wide main circumferential grooves GO, preferably 0.4 to 0.7 times GH.
If the depth BH is less than 0.3 times the main groove depth GH, the rigidity of the axially outer shoulder block part SB1 is not decreased, and the resistance to sideslip and resistance to wandering are decreased.
On the contrary, if the depth BH is more than 1.10 times the main groove depth GH, the rigidity of the axially outer

shoulder block part SB1 is excessively decreased, and uneven wear is liable to occur.

The axially outer shoulder block part SB1 is provided with at least one edge sipe ES extending circumferentially in parallel with the tread edge E.
In this embodiment, two edge sipes ES and ES are evenly disposed in the widthwise direction of the axially outer shoulder block part SB1 so as to divide this part into three axial regions having a substantially same width.

The width of the edge sipe ES is smaller than that of the narrow circumferential shoulder groove GB, and in the range of 0.2 to 1.5 mm, preferably less than 0.7 mm.

The mean depth EH of the edge sipe ES is 0.25 to 1.25 times the mean depth BH of the narrow circumferential shoulder groove GB. In this example, EH is about 0.8 times BH.
If the depth EH is less than 0.25 times the depth BH, the axial rigidity of the axially outer shoulder block part SB1 increases to lower the resistance to lateral skid and resistance to wandering.
If the depth EH is more than 1.25 times the depth BH, the rigidity decreases, and clacks are liable to occur at the sipe bottom, which results in tear-off of the tread rubber and therefore a decrease in the tread durability.

In this embodiment, the depth of the edge sipe ES and the depth of the narrow circumferential shoulder groove GB are constant in their longitudinal directions. But, the depth may be varied.

Further, the tread portion 12 is provided with a plurality of groove-side sipes S on at least one side of each of the symmetrically arranged paired main circumferential grooves GO.

Each groove-side sipe S is spaced apart from the main circumferential groove by an axial distance (1) of 0.06 to 0.25times the tread half-width TW.

The groove-side sipe S extends in parallel with the main circumferential groove GO or inclined at a small angle of not more than 5 degrees with respect to the main circumferential groove GO.

In this embodiment, on both sides of each of the axially outermost grooves GO2, therefore in the shoulder blocks SB and the middle tread blocks 5, continuous straight sipes are provided as groove-side sipes S.
The groove-side sipe S in the shoulder block SB is disposed in the axially inner shoulder block part SB2 to further divide this part SB2 into a wide main region B2 and a narrow lateral region B1.
The width SW and the depth of the groove-side sipe S are constant along the length thereof, but they may be varied within the respective ranges.

The width SW of the groove-side sipe S is in the range of 0.2 to 1.5 mm, preferably less than 0.7 mm.

The mean depth SH of the groove-side sipe S is 0.25 to 1.0 times the groove depth GH of the main circumferential

grooves GO. In this example, SH is about 0.5 times GH.
If the depth SH is less than 0.25 times the depth GH, the resistance to lateral skid is greatly decreased.
If the depth SH is more than 1.0 times the depth GH, the axial rigidity of the narrow lateral region B1 decreases to lower the resistance to lateral skid, and tear-off of the tread rubber is liable to occur to decrease the tread durability.

The circumferential length L of the narrow lateral region B1 is, as explained above, 3.0 to 20.0 times the groove width GW of the adjacent main circumferential grooves GO2.
If the length L is less than 3.0 times the width GW, the resistance to lateral skid is greatly decreased.
If the length L is more than 20.0 times the width GW, as the circumferentially pitches of the axial grooves g are increased, traction, breaking force and drainage are decreased.

In this embodiment, as the middle tread blocks 5 are also provided with groove-side sipe S, each middle tread block is axially divided into a wide main region B2 and a narrow lateral region B1 adjacent to the main groove GO2 similarly to the shoulder blocks SB.

Further, each shoulder block SB is provided in only the wide main region B2 with circumferentially spaced axial sipes LS.
The axial sipes LS in each main region B2 extend from the

narrow circumferential shoulder groove GB to the groove-side sipe S in parallel with each other and in parallel with the front/rear block edges or the axial grooves (g). Accordingly, the axial sipes LS are bent in the same manner as the axial grooves (g).

It is preferable that no axial sipe is formed in the axially outer shoulder block part SB1 and the narrow lateral region B1 to maintain the rigidity thereof. However, if the axial groove pitches are large and thereby the length of the narrow lateral region divided by two or more can satisfy the above condition, an axial sipe may be provided for example as shown in Fig.4. In Fig.4, only the narrow lateral region B1 is provided in the middle thereof with an axial sipe RS.

In this embodiment shown in Figs. 1-3, the central tread blocks 4 and
the middle tread blocks 5 excepting the respective narrow lateral regions B1 thereof are each provided with similar bent axial sipes LS extending across the block in parallel with each other and in parallel with the axial grooves.

In the present invention, the groove-side sipes can be formed on one side or both sides of each main circumferential groove GO1 so as to define a narrow lateral region B1 within the adjacent tread block.

Test tires of size 10.00R20 having the tread pattern and tire construction which are shown in Figs.1-3 were made by way of example only by varying the following parameters:

the width WSB1 of the axially outer shoulder block part SB1;

the depth BH of the narrow circumferential shoulder groove GB;

the depth EH of the circumferential edge sipe ES;

the groove depth SH of the groove-side sipe S;

the depth gH of the axial grooves (g);

the groove width SW of the groove-side sipe S; and

the circumferential length L of the narrow lateral region B1,

and the tires were tested for lateral skid.

Running a test vehicle on icy test course, lateral skid performance of each test tire was evaluated by a test driver.

The test tire was mounted on its regular rim of size 7.00T and inflated to 8.0 kg/sq.cm inner pressure. The tire load was 2700 kg.

The test results are indicated in Figs. 5-9, wherein the results are indicated by an index. The larger the index, the better the resistant to lateral skid.

Fig. 5 is a graph showing the lateral skid as a function of the quotient WSB1/TW of the width WSB1 of the axially outer shoulder block part SB1 divided by the tread half-width TW. (BH/GH = 0.8 and EH/BH = 1.0)

Fig. 6 is a graph showing the lateral skid as a function of quotients BH/GH and EH/BH;

the quotient BH/GH of the groove depth BH of the narrow circumferential shoulder groove GB divided by the groove depth GH of the wide main circumferential grooves G, and the quotient EH/BH of the groove depth EH of the circumferential edge sipe ES divided by the groove depth BH of the narrow circumferential shoulder groove GB.

Fig. 7 is a graph showing the lateral skid as a function of the quotient SH/GH of the groove depth SH of the groove-side sipe S divided by the groove depth GH of the wide main circumferential grooves GO. (gH/GH = 0.8, SW = 0.6mm and 1/GW = 1.0)

Fig. 8 is a graph showing the lateral skid as a function of the quotient gH/GH of the groove depth gH of the axial grooves (g) divided by the groove depth GH of the wide main circumferential grooves GO. (SH/GH = 0.8, SW = 0.6mm and 1/GW = 1.0)

Fig. 9 is a graph showing the lateral skid as a function of the width SW of the groove-side sipe S and the quotient L/GW of the circumferential length L of the narrow lateral region B1 divided by the groove width GW of the wide main circumferential grooves GO.

From the tests, it was confirmed that the tires according to the invention were superior in the resistance to lateral skid.

As explained above, in the tires according to the invention, the resistance to lateral skid during running on snowy and icy roads is improved while the traction and braking force are being maintained.

Further, the wandering is improved by the decreased lateral rigidity of the tread shoulder.

Furthermore, the movement of the axial ends of the circumferential parts of the shoulder block divided by the axial sipes are restricted by a direct support by the adjacently located circumferentially extending block part and an indirect support or the existence thereof, whereby uneven wear and tread rubber tear-off are reduced to improve durability.

Claims

1. A pneumatic tire comprising a tread portion having a pair of tread edges, wherein:

said tread portion is provided with at least two main circumferential grooves and with axial grooves to define tread blocks which are arranged in at least two circumferential rows, said tread blocks comprising shoulder blocks which are between each axially-outermost main circumferential groove and each tread edge, each of said shoulder blocks being provided with a narrow circumferential shoulder groove so as to subdivide said block axially into an axially-outer shoulder block part and an axially-inner shoulder block part, the axial width of the axially-outer shoulder block part, measured from said tread edge to said narrow circumferential shoulder groove being 0.06 to 0.25 times the tread half-width between one tread edge to a tire equator, and the mean groove depth of said narrow circumferential shoulder groove being 0.3 to 1.10 times the groove depth of said main circumferential grooves; and

each of said tread blocks in said at least two circumferential rows is provided with at least one sipe extending circumferentially of said tire to divide said tread block into at least two axial parts, said at least one sipe having a width of 0.2 to 1.5 mm, said at least one sipe being disposed in said axially-outer shoulder block part, the mean depth of each of said at least one sipe being 0.25 to 1.25 times the mean groove depth of said narrow circumferential shoulder groove.

2. The pneumatic tire according to claim 1, wherein:

said main circumferential grooves are two main circumferential grooves which are arranged at symmetrical axial positions with respect to said tire equator, each of said two main circumferential grooves defining a circumferential row of said tread blocks which is located adjacent to said groove and on one side of said groove;

each of said tread blocks is provided with a sipe extending continuously in substantially-parallel with said main circumferential groove so as to divide said tread block into a wide main region and a narrow lateral region on the main circumferential groove side, the circumferential length of said narrow lateral region being more than 3.0 times but less than 20.0 times the groove width of said main circumferential grooves;

the mean depth of each of said at least one sipe is 0.25 to 1.0 times the groove depth of said main circumferential grooves; and

the groove depth of said axial grooves is more than 0.40 times but not more than 1.0 times the groove depth of said main circumferential grooves.

3. The pneumatic tire according to claim 2, wherein said wide main region is provided with a plurality of circumferentially-spaced, axially-extending, axial sipes.

4. The pneumatic tire according to claim 1, claim 2 or claim 3, wherein:

said main circumferential grooves are straight grooves; and

said axial grooves are bent grooves.

5. A pneumatic tire comprising:

a tread portion having a pair of tread edges, wherein:

said tread portion is provided with two wide main circumferential grooves and with axial grooves extending between said wide main circumferential grooves and said tread edges so as to define tread shoulder blocks in two circumferential rows;

each of said shoulder blocks is provided with a narrow, circumferential shoulder groove so as to subdivide said block axially into an axially-outer shoulder block part, and an axially-inner shoulder block part, the groove width of said narrow circumferential shoulder groove is smaller than that of said wide main circumferential grooves, and being in the range of from 1.5 to 2.5 mm;

the mean groove depth of said narrow circumferential shoulder groove is 0.3 to 1.10 times the groove depth of said wide main circumferential grooves, and the axial width of said axially-outer shoulder block part, measured from said tread edge to said narrow circumferential shoulder groove being 0.06 to 0.25 times the tread half-width between one tread edge to a tire equator;

said axially-outer shoulder block part is provided with an edge sipe extending circumferentially of said tire, said axially-inner shoulder block part being provided with a groove-side sipe extending continuously in substantially parallel with said main circumferential groove so as to divide said inner part into a wide main region and a narrow lateral region on said main circumferential groove side;

said edge sipe and said groove-side sipe have widths which are smaller than that of said narrow circumferential shoulder groove and which are in the range of 0.2 to 1.5 mm;

said narrow lateral region has a circumferential length which is more than 3.0 times but less than 20.0 times the groove width of said main circumferential grooves and an axial width which is 0.06 to 0.25 times said tread half-width; and

said wide main region is provided with circumferentially-spaced, axial sipes extending axially from said narrow circumferential shoulder groove to said groove-side sipe.

6. The pneumatic tire according to claim 5, wherein

said main circumferential grooves are straight grooves extending in parallel with said tire equator;

said axial grooves are bent grooves;

said groove-side sipes and said edge sipes are straight sipes extending in parallel with said tire equator; and

said axial sipes are bent so as to extend in parallel with said axial grooves.

Fig. 1

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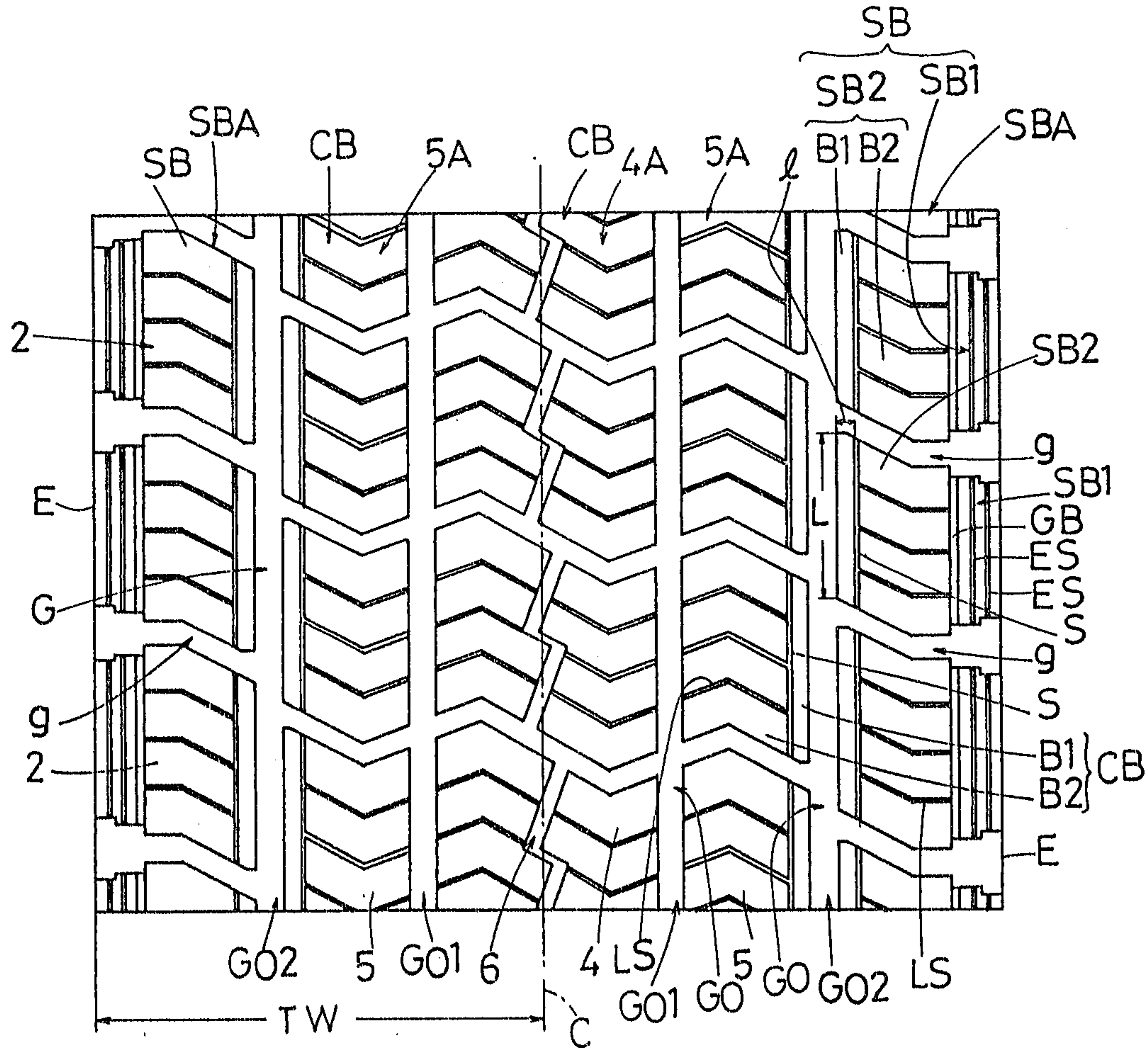

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Fig. 2

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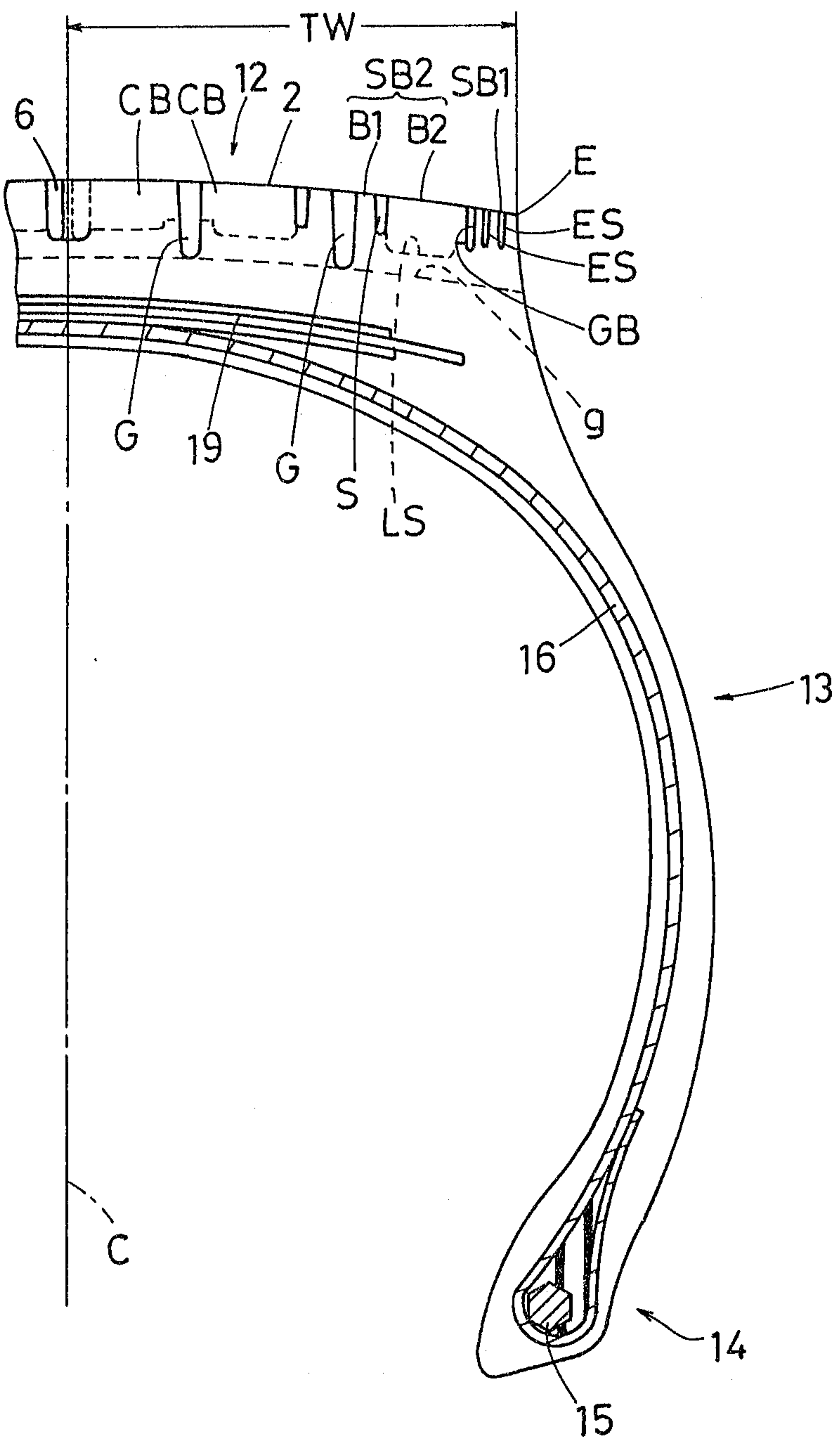

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Fig. 3

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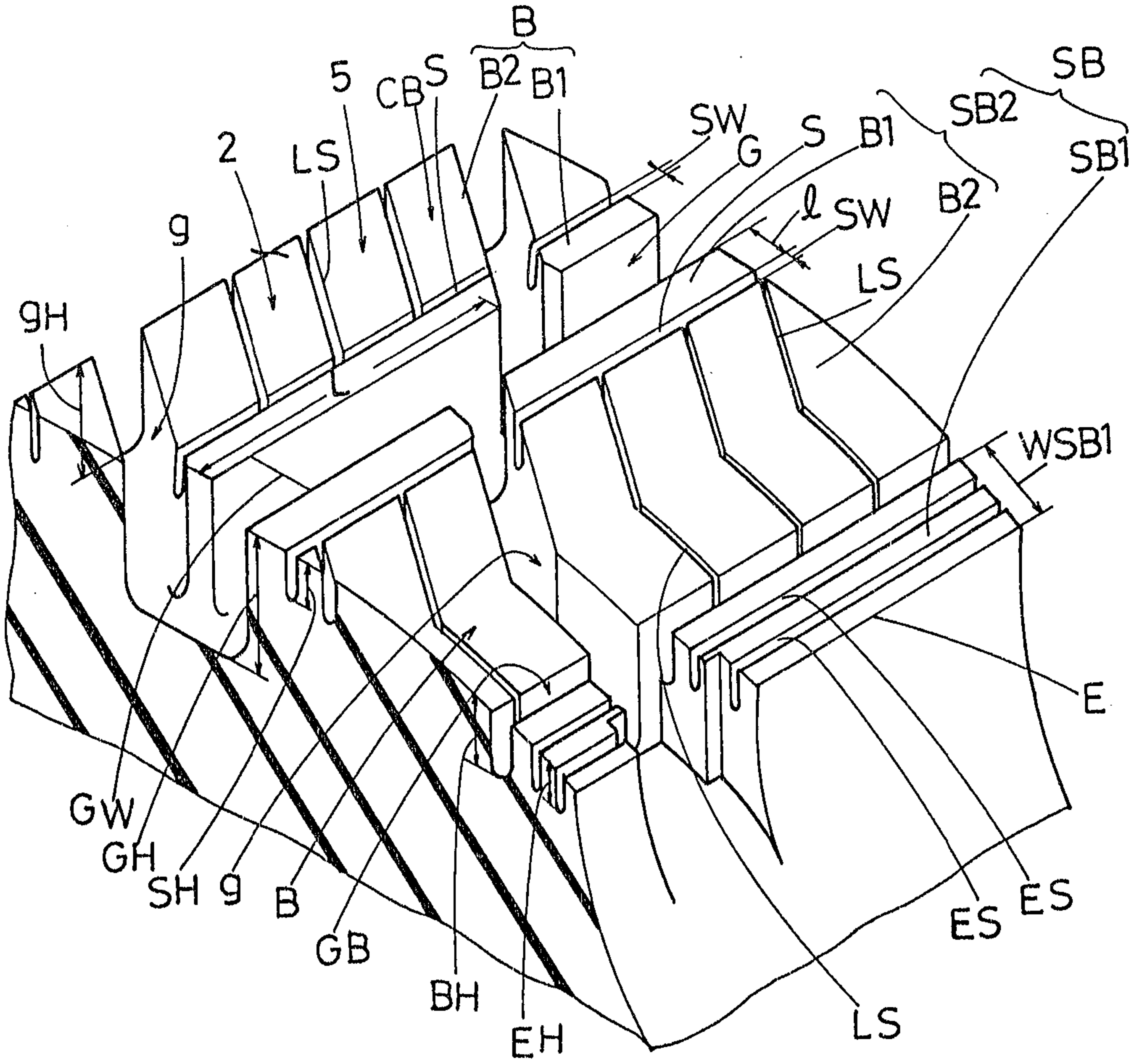

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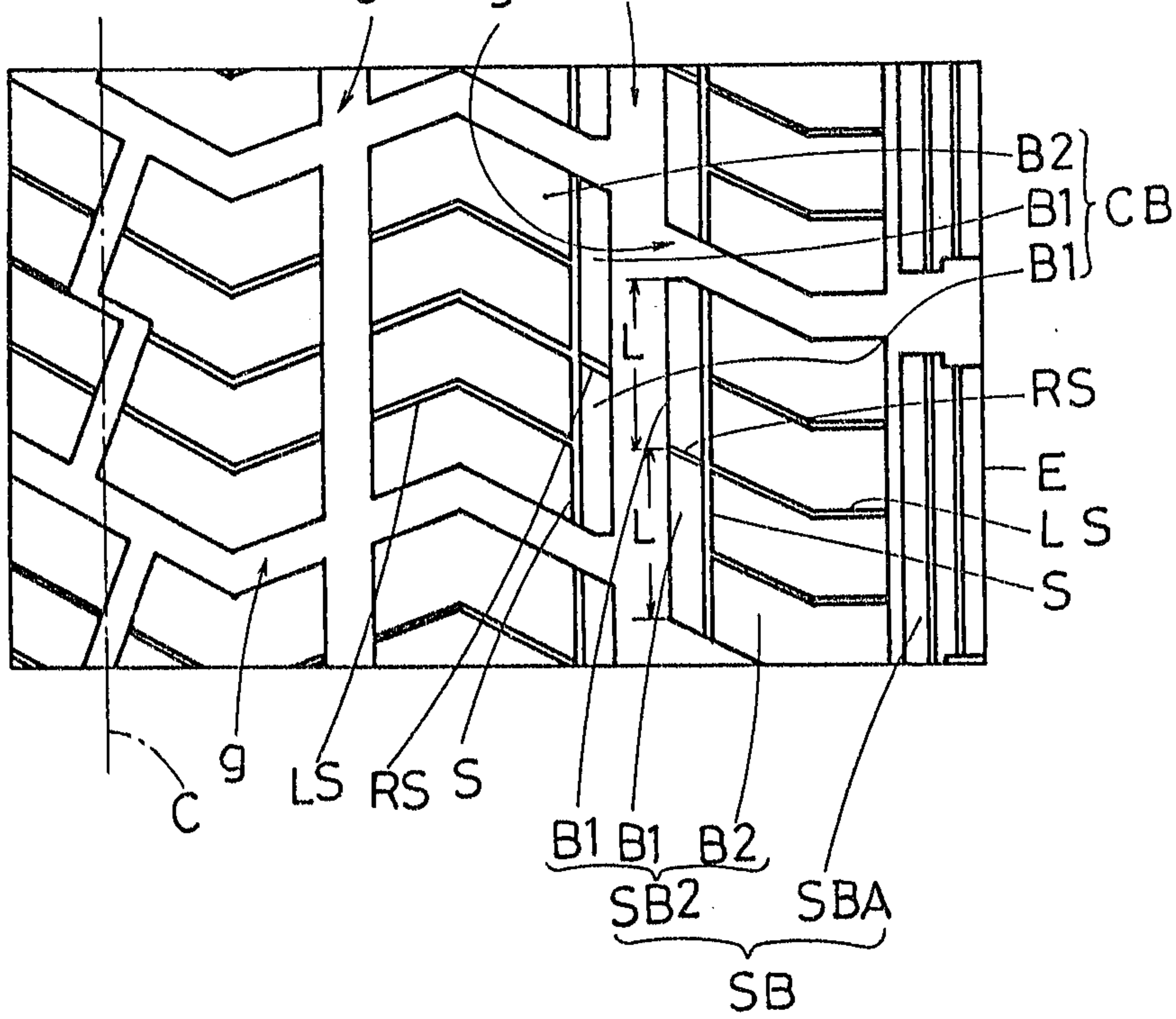
Fig. 4



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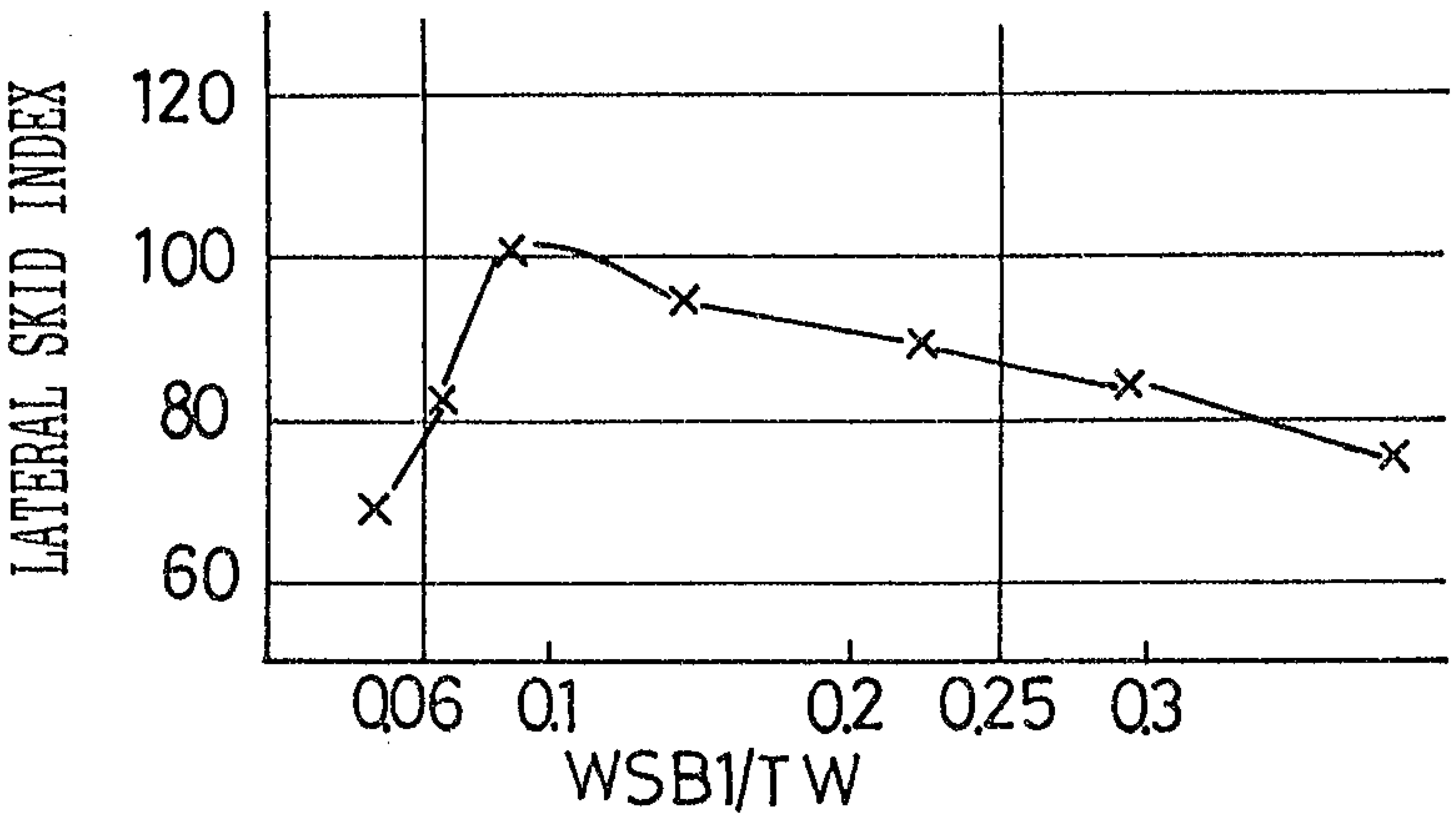

Fig. 5

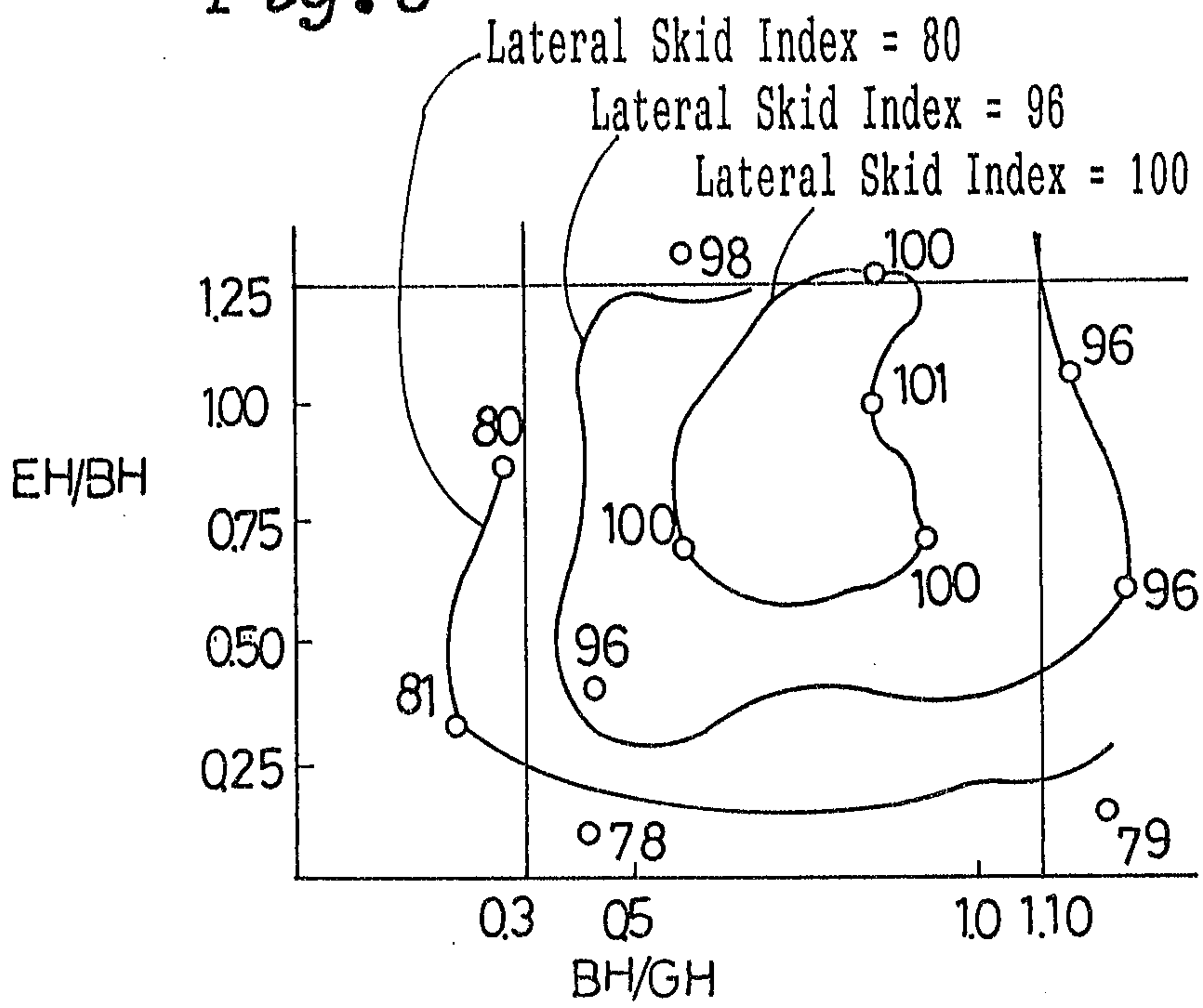

Fig. 6

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Fig. 7

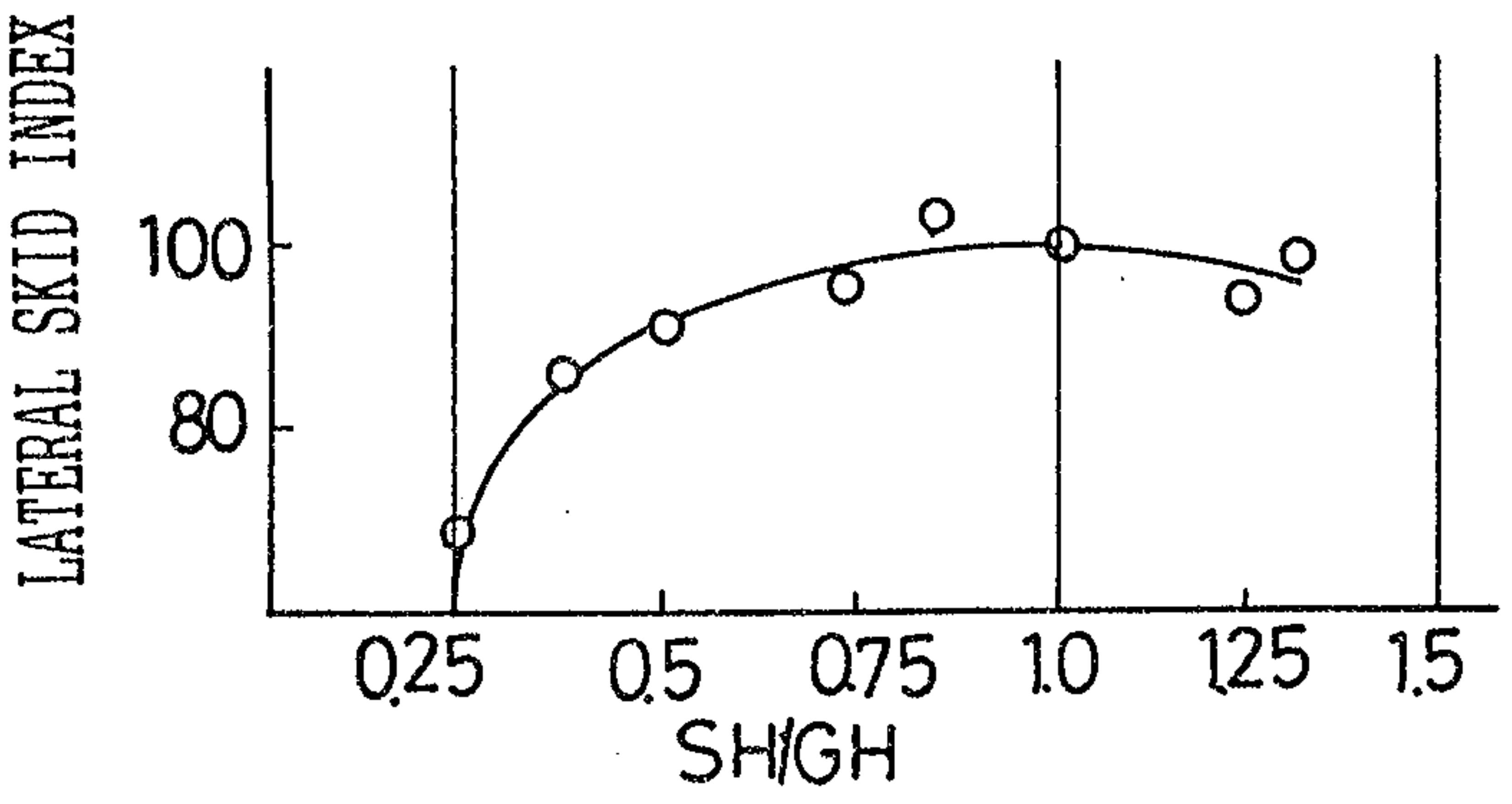

Fig. 8

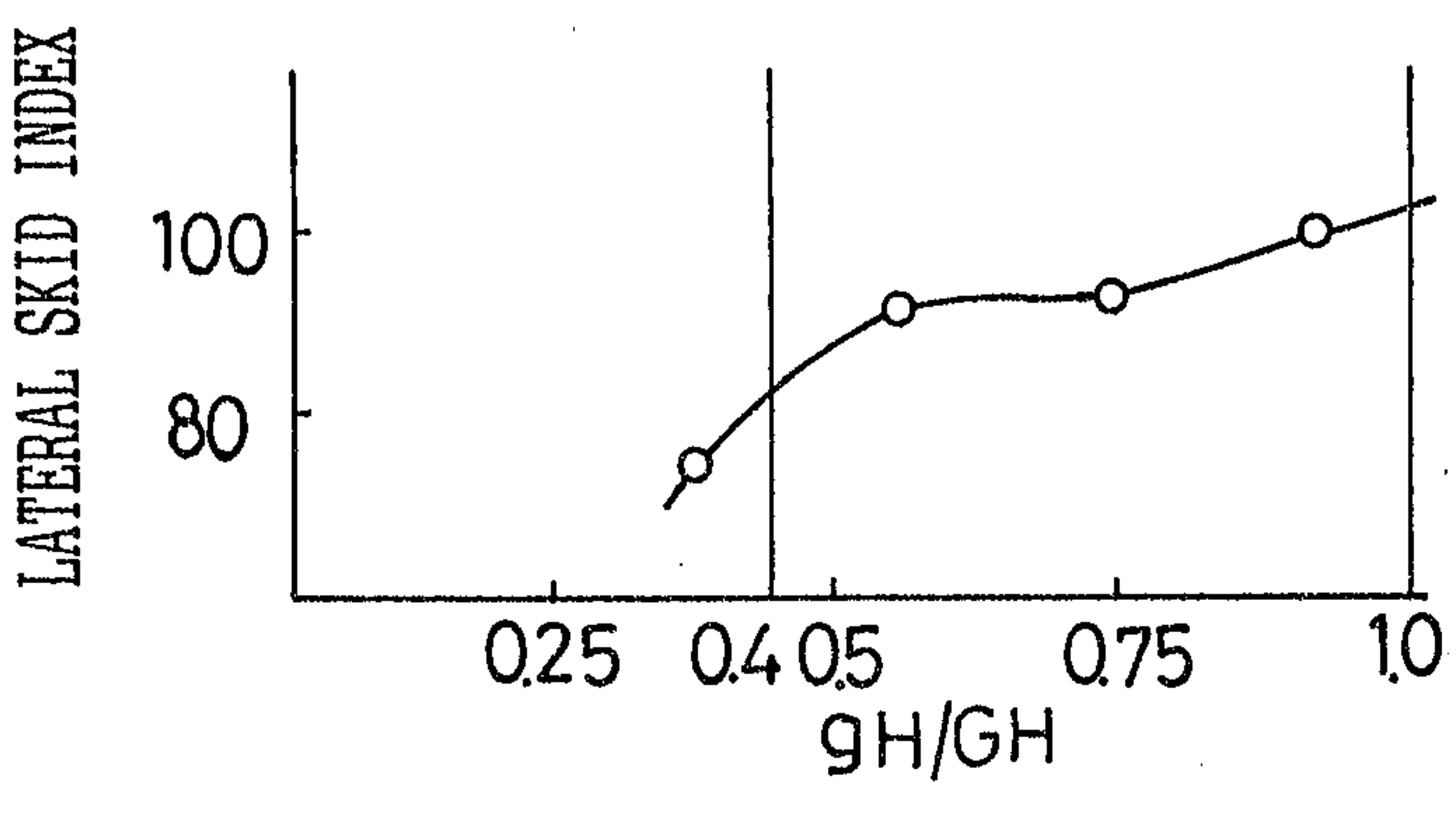

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Fig. 9

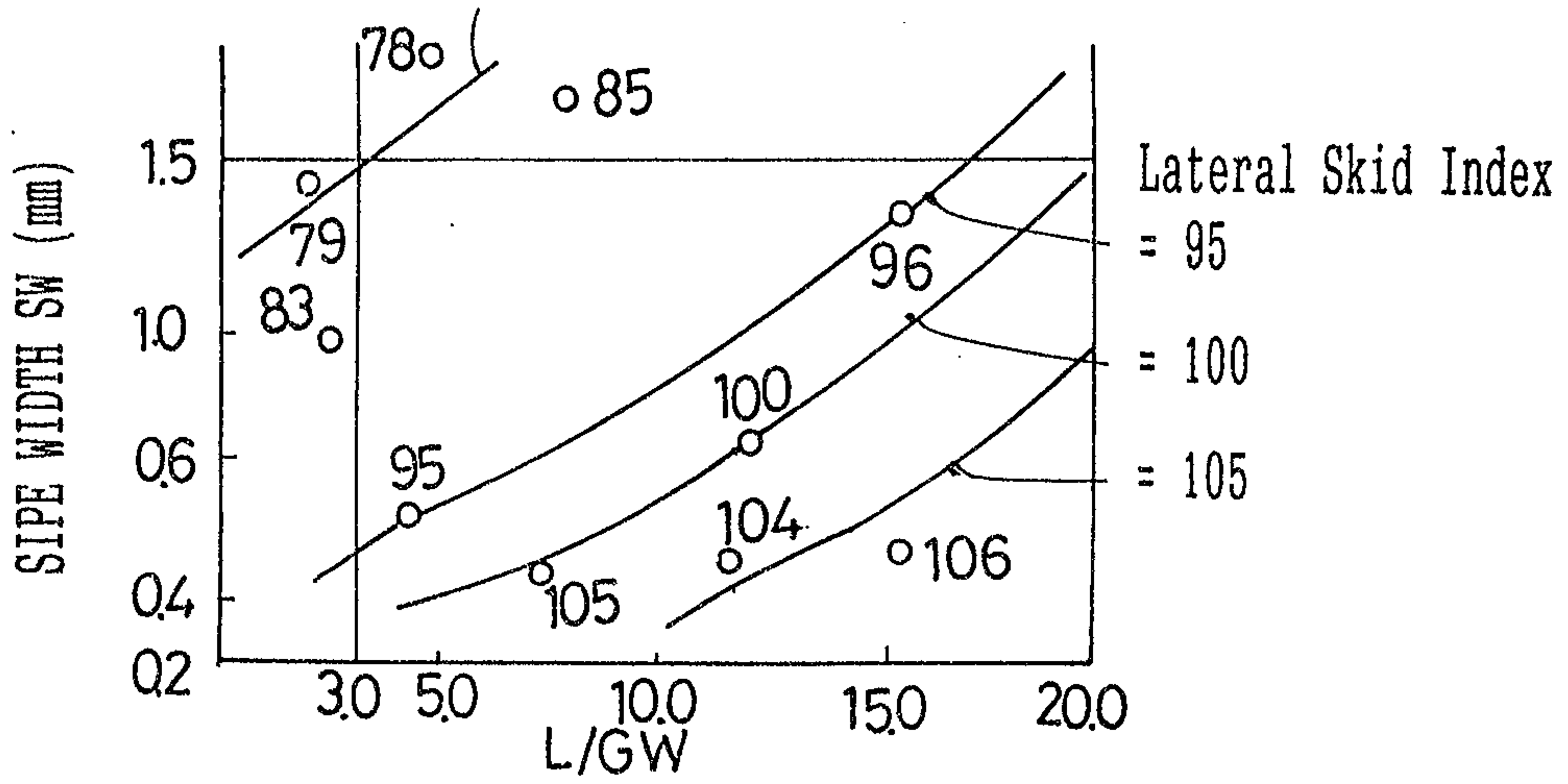
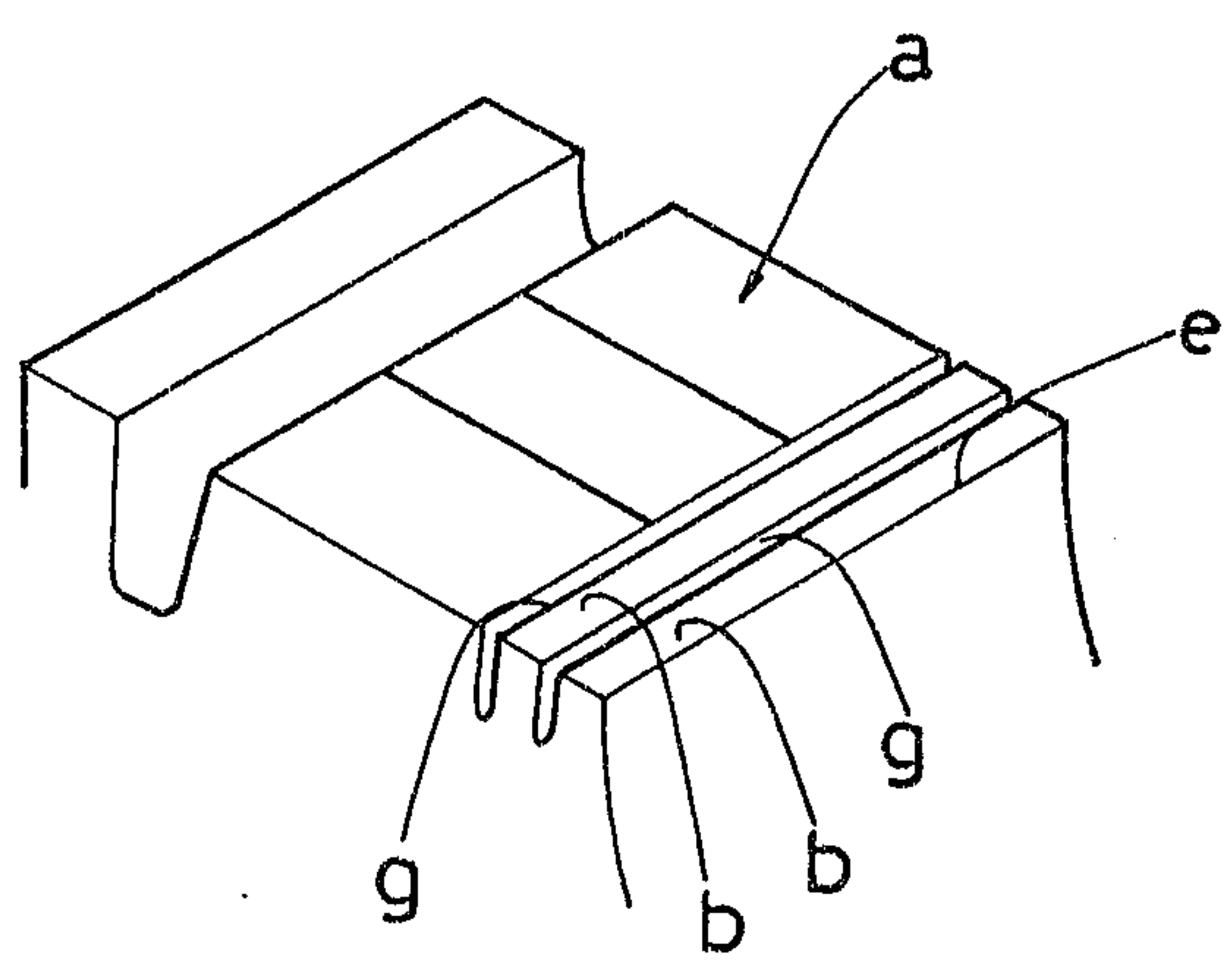


Fig. 10



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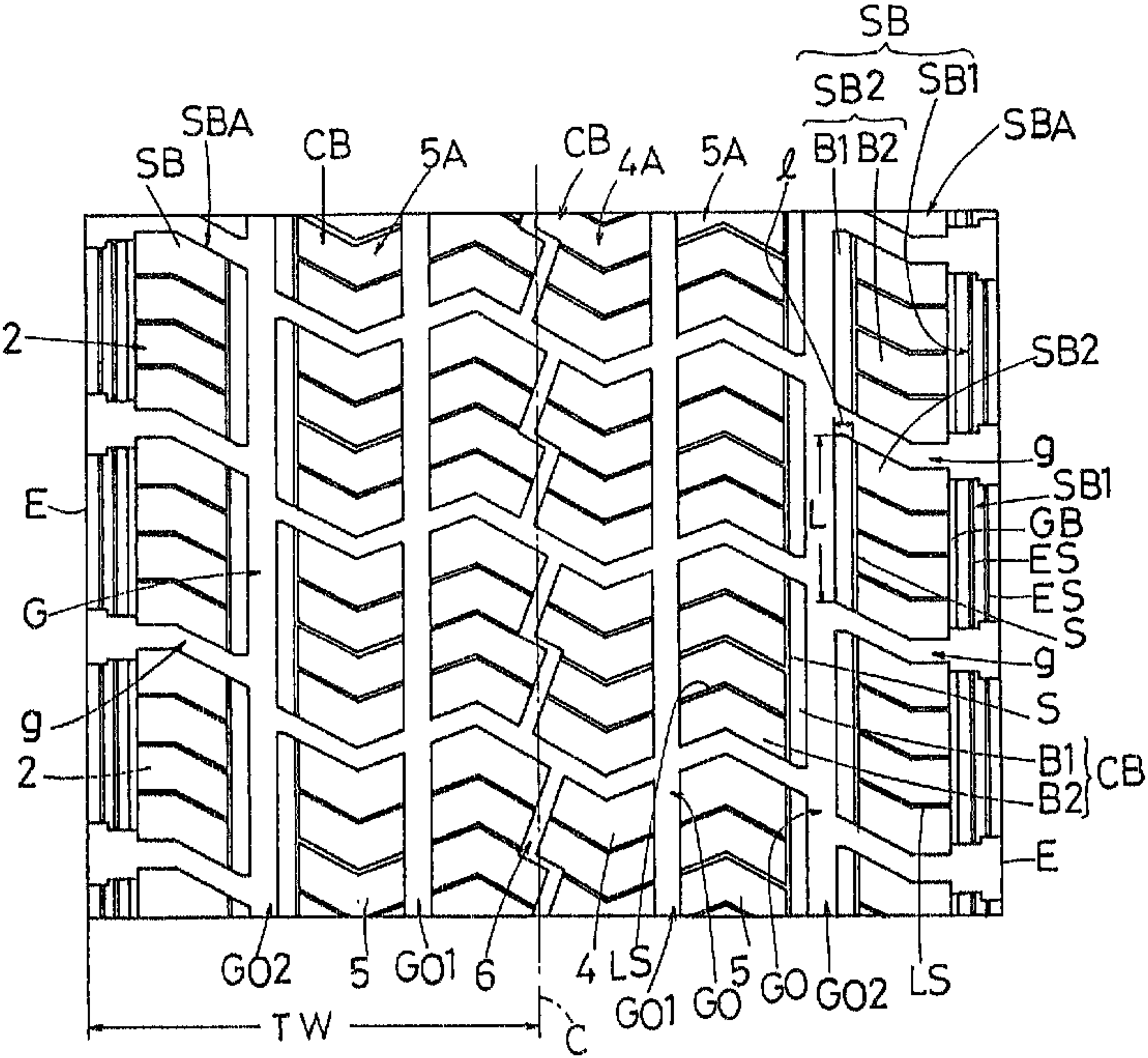
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