TIRE TREAD HAVING UNEVEN GROOVE WALLS
REIFENLAUFFLÄCHE MIT UNEBENEN NUTENWÄNDEN
BANDE DE ROULEMENT A PAROIS DE RAINURES IRREGULIERES

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References cited:
US-A- 2 661 041
US-A- 2 869 609
US-A- 3 951 193


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The invention relates to tires, and more particularly, to a tread for truck tires for long distance highway travel.

Highway travel, because it involves driving long distances in a substantially straight line with relatively few turns, normally causes low wear in truck tires. However, tires used on highways have been found to experience abnormal wear patterns, which typically appears in three different forms. One form, called “rail wear,” occurs where the edge of a rib wears differently than the main portion of the rib, and may appear as shallow pits or recesses at or near rib edges that eventually propagate into and across the rib. A second form, called “flat spotting,” usually occurs across the surface of a rib and results in a flat spot being generated in the normally curved surface of the rib. A third type of abnormal wear results in a depression of a rib surface about the entire circumference of the tire. Among other problems, abnormal wear can also generate noise and vibrations that may be transmitted through the vehicle suspension to the driver.

It is thought that stress concentrated at the rib edge contributes to the onset of abnormal wear. Accordingly, making the rib edges less stiff than the rest of the rib is believed to help alleviate abnormal wear. One approach along these lines has been to form the grooves between ribs with negatively sloped walls, that is, the grooves widen from the tread surface to the groove bottom. A difficulty with this approach is that these grooves are also more likely trap and retain stones, which can work down into the groove and damage the tire casing.

A tire according to the preamble of claim 1 to disclosed in JP 08 216 624A.

The present invention proposes a solution to abnormal wear in a tread that may be used for new tires or for retread tires.

According to the invention, a tire tread according to claim 1 is provided.

A unique feature of a preferred embodiment is that the side wall protrusions and recesses protrude and the side wall recesses may also be formed on the upper surfaces of the side wall waveforms.

The invention advantageously provides flexibility to the rib edges, helping to avoid the stress concentrations that initiate abnormal wear, by providing the cavities below the rib edges. In addition, the shape of the groove space helps avoid trapping stones.

The invention will become better understood by reference to the following detailed description in conjunction with the appended drawings, in which:

Figure 1 is a perspective view of a tire tread; Figure 2 is a top view of a portion of a tire tread looking perpendicularly into a groove illustrating a first embodiment of the invention; Figure 3 is a view of the tread of Figure 2 showing more detail; Figure 4 is a sectional view of the tire tread of Figure 2 taken along the lines 4-4; Figure 5 is a sectional view of the tire tread of Figure 2 taken along the lines 5-5; Figure 6 is a top view of a portion of a tire tread according to an alternative embodiment; Figure 7 is a sectional view of the tire tread of Figure 6 taken along the lines 7-7;
Figure 8 is a sectional view of the tire tread of Figure 6 taken along the lines 8-8; Figure 9 is a partial top view of a tire tread according to another alternative embodiment; Figure 10 is a sectional view of the tread of Figure 9 taken along the lines 10-10; Figure 11 is a sectional view of the tread of Figure 9 taken along the lines 11-11; Figure 12 is a top view of a portion of a tire tread according to yet another embodiment; Figure 13 is a sectional view of the tread of Figure 12 taken along the lines 13-13; and, Figure 14 is a sectional view of the tread of Figure 12 taken along the lines 14-14.

[0019] A truck tire is shown in perspective view in Figure 1. The tire 10 includes a mounting bead area 12, opposing side walls 14, and a tread 20 bonded on a summit 16. The tread 20 extends circumferentially around the tire. The tread 20 has an upper surface 22 that includes a plurality of circumferentially directed ribs 26 separated by grooves 24. The grooves 24 and ribs 26 shown in Figure 1 are formed with the edges following straight circumferential lines at the upper surface 22. As explained more fully below, alternatively, the groove edges can be contoured, for example, being zigzag or curved at the upper surface 22.

[0020] The invention relates to the shape of the groove walls. For simplicity in the following description, one groove will be described; however, the invention may be incorporated in any or all of the grooves in a tread, and the following description is intended to apply accordingly. The tire tread, which is intended usually for a steer position tire, is exemplary. As will be appreciated by those skilled in the art, the invention can be incorporated in any type of tire. A groove, as used herein, is distinguished from a sipe or incision as understood in the art. A groove is formed to be sufficiently wide so there is not normally contact between facing walls.

[0021] Figure 2 is a fragmentary plan view of the tread illustrating a groove 24 in accordance with the invention. For clarity, Figure 2 is shown without hidden lines, however, Figure 3 shows the view according to Figure 2 including details illustrated by hidden lines. Figures 4 and 5 are sectional views taken along the lines 4-4 and 5-5, respectively, in Figure 2.

[0022] The groove 24 includes opposing edges 30, 32 at the upper surface 22. Side walls 34, 36 of the groove 24 extend to a bottom wall 38 perpendicularly below the upper surface 22. According to the invention, the side walls 34, 36 are each shaped to follow a first waveform 40 at the groove bottom wall 38 and a second waveform 42, out of phase with the first waveform, at a level between the groove bottom wall and the upper surface 22. By waveform is meant a contour that includes curves or angles. Out of phase means that the waveforms are relatively shifted in the circumferential direction. According to a preferred embodiment of the invention, the waveforms are 180° out of phase, so that the crest or peak of one waveform is aligned perpendicularly with the recess of the other.

[0023] According to a preferred embodiment, the curves or angles are regularly repeating elements, forming, for example, sinusoidal waves, sawtooth waves, zigzags, or step waves. A particular preferred embodiment using a sinusoidal waveform is illustrated in Figures 2 and 3. In the figures, identical waveforms are used for the first 40 and second 42 waveform, for example, both waveforms being sinusoidal, as illustrated in Figures 2 and 3. Alternatively, different waveforms can be used for the first and second waveform.

[0024] As may be seen in particular in Figures 3, 4, and 5, the waveform shapes formed in the side walls 34, 36 present areas that alternately project and recess relative to reference planes R perpendicular to the bottom wall 38 and incident on the respective upper edges 30, 32 of the groove. The protrusions, that is, the portions projecting into the groove, advantageously narrow the groove opening to help prevent stones from being trapped in the groove. The recesses of the contour, the portions that are recessed relative to the reference planes R, provide flexibility to the respective upper edge 30, 32 by forming a concavity perpendicularly under the respective edge, allowing the upper edge some freedom to move vertically in response to a load. Each protrusion and each recess forms an apex defined by the second waveform at a point spaced from the respective upper edge and bottom wall. The protrusions and recesses are thus each surrounded by a base from which the side wall surfaces slope to the respective apex.

[0025] According to a preferred embodiment illustrated in Figures 2-5, the protrusions extend laterally or transversely at least to a circumferential centerline or midpoint of the groove, and more preferably, substantially across the width of the groove. The protrusions are not intended to contact the opposing wall under normal conditions so as not to disturb the flexibility provided to the corresponding upper edge of the groove wall.

[0026] Flexibility is also imparted to the upper edges 30, 32 for the side wall portions that include the protrusions by positioning the first waveform 40, which defines the bottom surface of the protrusion, to be transversely outward from the groove 24 relative to the respective upper edge. At the intersection with the bottom wall 38, the side walls 34, 36 follow the first waveform 40 in the recessed region beneath the protrusion. The side walls 34, 36 extend transversely outwardly from the groove center past a plane defined by the respective upper edges 30, 32, thus undercutting the upper edges. The recessed regions of the groove wall defined by the first waveform form a concavity directly below the respective upper edge. The concavity imparts flexibility to the upper edge by permitting some vertical movement of the edge in response to a load.

[0027] It is believed that waveforms according to the invention provide a substantially uniform flexibility to the
upper edges about the circumference of the tread. This, in turn, is believed to prevent or at least delay the onset of abnormal wear by avoiding high stress areas at the edges.

The amplitude of the protrusions and recesses, that is, the distance in the transverse direction that the protrusions and recesses extend from the reference plane, can be chosen to adjust the degree of flexibility imparted to the upper edges. Accordingly, the protrusion and recess amplitudes may differ for a single waveform, and the protrusion and recess amplitudes for the first and second waveform may also differ.

The tread 22 includes sipes 28 formed in the upper surface 22 and the uppermost portions of the projected portions of the side walls 34, 36. According to the illustrated embodiment in Figures 4 and 5, the sipes extend downward from the upper surface 22 of the tread about half of the groove depth, to about the level of the second waveform. As the tread wears, the sipe effective length will increase, as will be appreciated from the figures, which helps maintain tread performance.

Figure 6 shows an alternative embodiment in which the side walls 134, 136 are formed with staggered or out-of-phase sawtooth or zigzag waveforms. As shown in Figures 7 and 8, which are sections of the groove 24 shown in Figure 6, the first 140 and second 142 sinusoidal waveforms are contiguously connected to provide alternating protrusions and recesses in the form of angled concave and convex areas in the side walls.

Figures 7 and 8 show that the convex protrusions are provided flexibility by the positioning of the first waveform 140 farther from the groove than the respective upper edge 30, 32, as described above in connection with Figures 4 and 5.

The embodiment illustrated in Figures 6, 7, and 8 shows the protrusions of the second waveform 142 extending less than half of the width of the groove to illustrate an alternative to the substantially full groove width waveforms shown in Figures 2-5. Although not shown in Figures 6, 7, and 8, sipes may also be provided in the tread surface and projecting portions of the side walls as illustrated in Figure 2.

Figure 9 illustrates another embodiment of the invention in which the first waveform 240 and second waveform 242 are both step waves or block shaped waves. Figure 10 is a sectional view of the embodiment of Figure 9 taken along the lines 10-10, and Figure 11 is a sectional view taken along the lines 11-11 of Figure 9. The sectional views show that in profile, the first 240 and second 242 waveforms are contiguously connected to define zigzags, similar to the form shown in Figures 7 and 8. The first waveform 240, in the area where the second waveform 242 forms a protrusion, extends transversely outward from a groove centerline to form a cavity below the respective upper edge 30, 32 in the same manner as described above.

It is to be understood that the sectional views shown in the figures are not meant to define a particular waveform as requiring a match with the illustrated sectional profile. Those skilled in the art will understand, for example, that the zigzag form of Figure 6 may incorporate a curved sectional profile as in Figures 4 and 5. The other waveform embodiments similarly may be formed with any sectional profile.

According to another aspect of the invention, illustrated in Figure 12, the upper edges 330, 332 of the groove walls are also formed with a waveform in the circumferential direction. Figure 12 illustrates a groove in which the upper edges 330, 332 are formed with zigzag waveforms, and the side walls 334, 336 are also formed with staggered zigzag waveforms 340, 342. Sipes 28 are formed in the upper surface 22 and the upper portions of the side walls 334, 336, similar to those shown in Figure 2. The waveform of the upper edges 330, 332 is staggered or out of phase with relation to the second waveform 342, which is a preferred way to arrange the contours. The waveform of the upper edges 330, 332 may selectively be in phase with the first waveform 340, as illustrated in Figure 12.

The upper edges of the groove walls can be shaped with other forms, for example, sinusoidal waves or step waves, which may not necessarily be the same as the waveforms incorporated in the groove side walls. For example, a groove may be formed with zigzag upper edges and sinusoidal side walls contours.

The staggered waveform contours of the side walls may be incorporated in transversely extending grooves also.

The invention has been described in terms of preferred principles, structure, and embodiments. Those skilled in the art will recognize that changes to the described structure can be made without departing from the scope of the invention as defined by the following claims.

**Claims**

1. A tread for a tire, the tread comprising an upper surface (22) and having at least one circumferentially extending groove (24) formed therein, the groove being bounded by a bottom wall (38) and opposing side walls (34, 36), wherein each side wall is formed at the bottom wall with a first waveform (40) extending in the circumferential direction, and at a level between the upper surface and the bottom wall is shaped with a second waveform (42) extending in the circumferential direction, characterized in that the first waveform and the second waveform are mutually out of phase so that each side wall (34, 36) has, at the level of the second waveform, a contour of alternating protruding and recessed portions.

2. The tread as claimed in claim 1, wherein in each of the protruding portions of each side wall, a bottom
edge of the side wall is transversely outward from a groove center farther than a respective upper edge of said side wall in the protruding portion.

3. The tread as claimed in claim 1 or in claim 2, wherein sipes (28) are formed in the upper surface (22) of the tread to extend to upper edges (30, 32) of the groove and into the protruding portions of the side walls.

4. The tread as claimed in any of claims 1 to 3, wherein opposing edges (30, 32) of the groove at the upper surface (22) are shaped in a third waveform (330, 332), the third waveform and the second waveform (340, 342) being out of phase in the circumferential direction.

5. The tread as claimed in any of claims 1 to 4, wherein the first and second waveforms (40, 42) have mutually different amplitudes with respect to a perpendicular reference line incident on the respective groove upper edge (30, 32).

6. The tread as claimed in any of claims 1 to 5, wherein protruding portions of the second waveform (42) of each side wall extend transversely past a circumferential centerline of the groove.

7. The tread as claimed in any of claims 1 to 6, wherein said at least one circumferentially extending groove comprises a plurality of circumferential grooves.

8. The tread as claimed in any of claims 1 to 3, wherein opposing edges (30, 32) of the groove (24) at the upper surface (22) are linear in the circumferential direction.

9. The tread as claimed in any of claims 1 to 8, wherein the first waveform (40) and second waveform (42) are both sinusoidal waves.

10. The tread as claimed in any of claims 1 to 9, wherein at least one the first, second or third waveforms is one of a sine wave, a zigzag wave, and a step wave.

11. The tread as claimed in any of claims 1 to 10, further comprising at least one transversely directed groove, the transverse groove having a depth substantially perpendicular to the upper surface, a bottom wall, and opposing side walls, wherein at the bottom wall the opposing side walls are formed in a first waveform, and at a level between the upper surface and the bottom wall the opposing side walls are shaped in a second waveform, the first waveform and the second waveform being out of phase so that each side wall has, at the level of the second waveform, a contour of alternating protruding and recessed portions.

**PATENTANSPRÜCHE**

1. Reifenprofil für einen Luftreifen, wobei das Reifenprofil eine obere Oberfläche (22) umfasst und zu mindest eine darin ausgebildete, sich in Umfangsrichtung erstreckende Profilrille (24) aufweist, die Profilrille von einem Profilgrund (38) und einander gegenüberliegenden Seitenwandungen (34, 36) begrenzt wird und in der Profilrille am Profilgrund jede Seitenwandung mit einer sich in Umfangsrichtung erstreckenden ersten Kurvenform (40) und auf einer Höhe zwischen der oberen Oberfläche und dem Profilgrund mit einer sich in Umfangsrichtung erstreckenden zweiten Kurvenform (42) ausgestaltet ist. **dadurch gekennzeichnet, dass** die erste Kurvenform und die zweite Kurvenform gegeneinanderphasenverschoben sind, sodass jede Seitenwandung (34, 36) auf Höhe der zweiten Kurvenform eine Kontur mit abwechselnd hervortretenden und zurücktretenden Bereichen aufweist.

2. Reifenprofil nach Anspruch 1, worin in jedem hervortretenden Bereich einer jeder Seitenwand die unteren Kante der Seitenwand sich weiter außerhalb des Zentrums der Profilrille befindet als die entsprechende obere Kante dieser Seitenwandung im hervortretenden Bereich.

3. Reifenprofil nach Anspruch 1 oder Anspruch 2, worin in der oberen Oberfläche (22) des Reifenprofils Lamellen ausgebildet sind, die sich zu den oberen Kanten (30, 32) der Profilrille und in die hervortretenden Bereiche der Seitenwandungen erstrecken.

4. Reifenprofil nach einem der Ansprüche 1 bis 3, worin einander gegenüberliegende Kanten (30, 32) der Profilrille an der oberen Oberfläche (22) in einer dritten Kurvenform (330, 332) ausgestaltet sind und wobei die dritte Kurvenform und die zweite Kurvenform (340, 342) in Umfangsrichtung gegeneinanderphasenverschoben sind.

5. Reifenprofil nach einem der Ansprüche 1 bis 4, worin die erste und zweite Kurvenform (40, 42) bezüglich einer senkrecht auf die entsprechende obere Kante (30, 32) der Profilrille auftreffenden Referenzlinie wechselseitig unterschiedliche Auslenkungen aufweisen.

6. Reifenprofil nach einem der Ansprüche 1 bis 5, worin hervortretende Bereiche der zweiten Kurvenform (42) einer jeden Seitenwandung sich quer über die umlaufende Mittellinie der Profilrille hinaus erstrecken.
1. Bande de roulement pour pneu, la bande de roulement comprenant une surface supérieure (22) et comportant au moins une rainure s'étendant d'une façon circonférentielle (24), la rainure étant définie par une paroi inférieure (38) et par des parois latérales opposées (34, 36), dans laquelle chaque paroi latérale présente à la paroi inférieure une première forme d'onde (40) s'étendant dans la direction circonférentielle, et présente à un niveau entre la surface supérieure et la paroi inférieure une deuxième forme d'onde (42) s'étendant dans la direction circonférentielle, caractérisée en ce que les premiè red deuxièmes formes d'onde sont mutuellement déphasées de sorte que chaque paroi latérale (34, 36) présente, au niveau de la deuxième forme d'onde, un profil comprenant des parties saillantes et des parties creuses en alternance.

2. Bande de roulement selon la revendication 1, dans laquelle, dans chacune des parties saillantes de chaque paroi latérale, un bord inférieur de la paroi latérale est saillant transversalement vers l'extérieur à partir du centre d'une rainure plus loin qu'un bord supérieur respectif de ladite paroi latérale dans la partie saillante.

3. Bande de roulement selon la revendication 1 ou la revendication 2, dans laquelle des lamelles (28) sont formées dans la surface supérieure (22) de la bande de roulement et s'étendent jusqu'aux bords supérieurs (30, 32) de la rainure et dans les parties saillantes des parois latérales.

4. Bande de roulement selon l'une quelconque des revendications 1 à 3, dans laquelle les bords opposés (30, 32) de la rainure à la surface supérieure (22) sont configurés dans une troisième forme d'onde (330, 332), la troisième forme d'onde et la deuxième forme d'onde (340, 342) étant déphasées dans la direction circonférentielle.

5. Bande de roulement selon l'une quelconque des revendications 1 à 4, dans laquelle les premières et secondes formes d'onde (40, 42) présentent des amplitudes mutuellement différentes par rapport à une ligne de référence perpendiculaire incidente sur le bord supérieur de rainure respectif (30, 32).

6. Bande de roulement selon l'une quelconque des revendications 1 à 5, dans laquelle les parties saillantes de la deuxième forme d'onde (42) de chaque paroi latérale s'étendent transversalement au-delà d'un axe médian circonférentiel de la rainure.

7. Bande de roulement selon l'une quelconque des revendications 1 à 6, dans laquelle ladite au moins une rainure s'étendant d'une façon circonférentielle comprend une pluralité de rainures circonférentielles.

8. Bande de roulement selon l'une quelconque des revendications 1 à 3, dans laquelle les bords opposés (30, 32) de la rainure (24) à la surface supérieure (22) sont linéaires dans la direction circonférentielle.

9. Bande de roulement selon l'une quelconque des revendications 1 à 8, dans laquelle la première forme d'onde (40) et la deuxième forme d'onde (42) sont toutes les deux des ondes sinusoidales.

10. Bande de roulement selon l'une quelconque des revendications 1 à 9, dans laquelle au moins une des premières, deuxième et troisième formes d'onde est...
soit une onde sinusoidale, soit une onde en zigzag, soit une onde étagée.

11. Bande de roulement selon l'une quelconque des revendications 1 à 10, comprenant en outre au moins une rainure orientée transversalement, la profondeur de la rainure transversale étant essentiellement perpendiculaire à la surface supérieure, une paroi inférieure et des parois latérales opposées, dans laquelle, à la paroi inférieure, les parois latérales opposées présentent une première forme d'onde, et à un niveau entre la surface supérieure et la paroi inférieure, les parois latérales opposées présentent une deuxième forme d'onde, la première forme d'onde et la deuxième forme d'onde étant déphasées de sorte que chaque paroi latérale présente, au niveau de la deuxième forme d'onde, un profil comprenant des parties saillantes et des parties creuses en alternance.