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(54) Title: TRUCK TIRE TREAD WITH ANGLED RIBS HAVING CHAMFERS ON LEADING EDGE

(57) Abstract: A heavy truck tire tread is provided with a tread groove that is not oriented completely in the longitudinal direction, the tread groove is at least partially defined by a leading edge wall and a trailing edge wall and a bottom surface. The leading edge wall has a bottom portion and a chamfer, and the bottom portion extends from the bottom surface. The chamfer extends from the bottom portion to the outer surface of the tread. An amount of extension from the bottom surface along the bottom portion and the chamfer to the outer surface is greater than an amount of extension from the bottom surface along the trailing edge wall to the outer surface. An orientation of the chamfer relative to the thickness direction remains constant along at least a portion of the length of the chamfer.

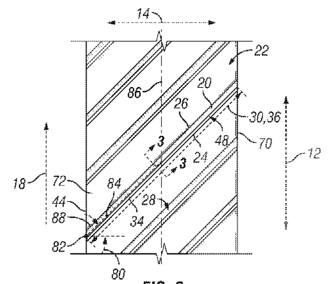

FIG. 2

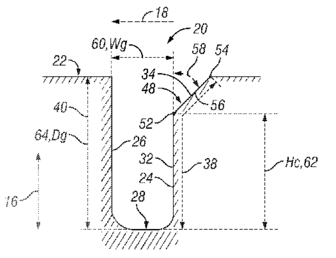

FIG. 3

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TRUCK TIRE TREAD WITH ANGLED RIBS HAVING CHAMFERS ON LEADING EDGE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority to PCT/US19/31776 filed on May 10, 2019 and entitled “Truck Tire Tread with Angled Ribs Having Chamfers on Leading Edge.” The entire contents of PCT/US19/31776 are incorporated by reference herein in their entirety for all purposes.

FIELD OF THE INVENTION

[0002] The subject matter of the present invention relates to a truck tire that has a higher contact surface ratio with protection again stone retention. More particularly, the present application involves a truck tire tread that features an angled groove pattern that have chamfers on their leading edges to reduce the occurrences of stone retention.

BACKGROUND OF THE INVENTION

[0003] Manufacturers of heavy commercial vehicle tires have made significant progress in developing tire architectures and tire materials that allow them to increase the wear resistance of tire treads and reduce the rolling resistance of tires while at the same time improving their level of grip and resistance to road hazard. Tread patterns that have higher contact surface ratios have an improved wear and/or rolling resistance performance. This ratio may be increased by reducing the widths of the grooves of the tread. However, when grooves are narrowed into a range of about five to ten millimeters, the odds of trapping a stone within the grooves increase. These stones could drill down into the bottom of the grooves and cause damage to the under-tread and potentially expose the reinforcing crown plies to moisture and subsequent corrosion. If bad enough, this stone drilling could render the truck tire non-retreadable.

[0004] Techniques employed to limit stone retention in tires include the provision of stone ejectors, high included angles in groove walls, variable width grooves, variable angled groove walls, and groove wall stone blockers. These features for the most part involve having a further opening of the groove to accommodate the feature, or a reduction of the groove volume for when the tire is in its worn state which is less than 50% of its tread life remaining. Increasing the opening of the grooves decreases the contact surface ratio of the tire thus decreasing the desired wear and/or rolling resistance improvement, and a reduction of the groove volume of the worn tire will decrease the wet and snow traction performance. It is known to have tread designs that feature grooves that are arranged in a diagonal pattern to achieve different performance trade-offs. Such tread designs could have a high contact surface ratio and yet maintain good traction performance, but involves the decreasing of groove width that will increase stone retention. A mechanism for decreasing stone retention in tread designs that have diagonal grooves would allow for benefits to be achieved without accepting at least one associated cost trade off.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures, in which:

[0006] Fig. 1 is a perspective view of a heavy truck tire.

[0007] Fig. 2 is top view of tread in accordance with one exemplary embodiment.

[0008] Fig. 3 is cross-sectional view taken along line 3-3 in Fig. 2.

[0009] Fig. 4 is a top view of tread in accordance with another exemplary embodiment.

[0010] Fig. 5 is a cross-sectional view taken along line 5-5 in Fig. 4.

[0011] Fig. 6 is a top view of tread in accordance with another exemplary embodiment.

[0012] Fig. 7 is a cross-sectional view taken along line 7-7 in Fig. 6.

[0013] Fig. 8 is a top view of tread in accordance with another exemplary embodiment.

[0014] Fig. 9 is a cross-sectional view taken along line 9-9 in Fig. 8.

[0015] Fig. 10 is a cross-sectional view of the tread groove in accordance with another exemplary embodiment.

[0016] Fig. 11 is a perspective view of a portion of the tread in which the width of the chamfer changes at different portions along the length of the chamfer in accordance with another exemplary embodiment.

[0017] Fig. 12 is a perspective view of a portion of the tread in which in which different portions of the chamfer have different orientations in accordance with another exemplary embodiment.

[0018] Fig. 13 is a top view of tread that has intermittent chamfers in accordance with another exemplary embodiment.

[0019] The use of identical or similar reference numerals in different figures denotes identical or similar features.

DETAILED DESCRIPTION OF THE INVENTION

[0020] Reference will now be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, and not meant as a limitation of the invention. For example, features illustrated or described as part of one embodiment can be used with another embodiment to yield still a third embodiment. It is intended that the present invention include these and other modifications and variations.

[0021] The present invention provides for a tread 10 for a heavy duty truck tire 68 that has a tread groove 20 that is not oriented completely in a longitudinal direction 12 or a lateral direction 14. The leading edge wall 24 of the tread groove 20 has a chamfer 34 that functions to limit stone retention to help prevent stones from being caught into the tread groove 20 and damaging the tread 10. The trailing edge wall 26 could include a chamfer, but preferably does not include a chamfer in most embodiments. The chamfer 34 on the leading edge wall 24 is effective in the first part of the tread 10 life. The first part of the tread 10 life is also the stage of the tread 10 life that is most likely to catch a stone into one of the tread grooves 20.

[0022] Fig. 1 shows a tire 68 that is a heavy duty truck tire 68. In this regard, the tire 68 is not designed for nor used with a car, motorcycle, or light truck (payload capacity less than 4,000 pounds), but is instead designed for and used with heavy duty trucks such as 18 wheelers, garbage trucks, or box trucks. The tire 68 may be a steer tire, a drive tire, a trailer tire, or an all position tire. The tire 68 includes a casing 66 onto which a tread 10 is disposed thereon. The tread 10 can be manufactured with the casing 66 and formed as a new tire 68, or the tread 10 can be a retread band that is attached to the casing 66 at some point after the casing 66 has already been used to form a retreaded tire 68. This is the case with all of the designs shown and described herein. They may all be tread designs of a brand new tire 68, or may be tread designs of a tread 10 for use in a retread tire 10. The central axis of the tire 68 extends through the center of the casing 66, and the lateral direction 14 of the tire 68 is parallel to the central axis. The radial direction 16, referred to also as the thickness direction 16, of the tire 68 is perpendicular to the central axis and the tread 10 is located farther from the central axis in the thickness direction 16 than the casing 66. The tread 10 extends all the way around the casing 66 in the circumferential direction 12, also referred to as the longitudinal direction 12, of the tire 68 and circles the central axis 360 degrees. The tread 10 includes a series of grooves and ribs that form a tread pattern. A rolling tread width extends in the lateral direction 14 from one shoulder tread edge 44 of the tread 10 to an opposite shoulder tread edge 70. The rolling tread width represents that portion of the tread 10 that engages the ground through normal operation of the tire 68, and the shoulder tread edges 44, 70 may engage the ground as well as the area between these locations in the lateral direction 14.

[0023] The tread 10 can be part of a tire 68 or a retread band that is produced and subsequently attached to a casing 66 to form a retread tire 68. The same tread pattern can repeat throughout the entire longitudinal length of the tread 10. The tread 10 has a tread groove 20 and additional tread grooves that are in sequence next to one another in the longitudinal direction 12. The tread grooves 20 can be variously shaped and have widths that can be greater than 2 millimeters. The shape of the center portion of the tread grooves 20 can be different than the shape of the shoulder portion of the tread grooves 20. A rib 72 is defined between the tread grooves 20 in the longitudinal direction 12. The rib 72 is not a circumferential rib 72 in that it does not extend all the way around the tread 10 in the longitudinal direction 12. Instead, the rib 72 extends from the tread edge 44 to the center of the tread 10. The rib 72 is angled relative to the longitudinal direction 12 so that the rib 72 extends so as to have a component of extension in both the longitudinal direction 12 and in the lateral direction 14. In contrast, a circumferential rib 72 would have a component of extension in the longitudinal direction 12 and no component of extension in the lateral direction 14.

[0024] The tread grooves 20 are likewise not circumferential grooves in that they extend so as to have a component of extension in both the longitudinal direction 12 and the lateral direction 14. The tread grooves 20 may extend from the shoulder edge 44 and terminate at some point at or near the center of the tread 10. Other tread grooves 20 could extend from the tread edge 70 to the center of the tread 10. In other embodiments, the tread grooves 20 and ribs 72 need not start at the tread edges 44, 70 and/or need not extend to the center. The tread grooves 20 may engage other grooves of the tread 10, and the ribs 72 between the tread grooves 20 may engage other ribs 72 of the tread 10 in other arrangements. The tread grooves 20 and ribs 72 have different components in the longitudinal and lateral directions 44, 70 along their lengths and as shown in Fig. 1, their angles change once. In other embodiments, the tread grooves 20 and rib 72 can have the same components of lateral and longitudinal extensions along their entire lengths. This would result in the tread grooves 20 and ribs 72 being straight in shape although angled relative to the longitudinal direction 12. In other arrangements, the tread grooves 20 and rib 72 may curve or have two, three, four, or more angular changes along their lengths.

[0025] The ribs 72 are located between the tread grooves 20 and can extend along to and terminate at the inboard most extensions of the tread grooves 20. The ribs 72 could also be thought of as terminating at a groove that the tread grooves 20 intersect near the center of the tread 10, but such an intersecting groove is not shown in Fig. 1. Further, the rib 72 may in some embodiments extend beyond the tread grooves 20 in the lateral and longitudinal directions 14, 12 until such time as the rib 72 terminates at a combination of a groove and another tread extending in from an opposite edge of the tread, such as that shown in Fig. 1.

[0026] The rolling tread width extends from the tread edge 44 to tread edge 70 in the lateral direction 14 and is the portion of the tread 10 that engages the ground during operations of the tire 68. The rib 72 extends a large amount in the lateral direction 14. With respect to the rolling tread width, the rib 72 extends at least 30% of the rolling tread width in the lateral direction 14. This rib 72 design thus distinguishes it from a block or other smaller feature proximate to the tread edge 44.

[0027] The tread 10 is directional in that it is designed for forward rotation of the tire 68. The rolling direction 18 is the direction in the longitudinal direction 12 the tread 10 is designed to rotate. The tread groove 20 extends into the tread 10 from an outer surface 22 of the tread 10 and includes a bottom surface 28 bounded on opposite sides by a leading edge wall 24 and a trailing edge wall 26. The leading edge wall 24 enters the contact patch of the tire 68 second as the tire 68 rotates in the rolling direction 18. The trailing edge wall 26 enters the contact patch of the tire 68 first before the leading edge wall 24. The bottom surface 28 may extend from the leading edge wall 24 to the trailing edge wall 26 and can open into the tread edge 44 and can terminate on its opposite end into the rubber of the tread 10. The tread 10 going around the entire tire 68 can be directional so that it is designed to roll in one direction to achieve desired rolling performance in this one direction. The tread 10 may still rotate in the opposite direction from the desired rolling direction 18, but may not experience the designed for performance in this direction.

[0028] Fig. 2 shows an alternate embodiment of the tread 10 that again features non-circumferential tread grooves 20, but has these tread grooves 20 extending completely from one of the tread edges 44 to the other tread edge 70. The tread grooves 20 are open at both of the tread edges 44, 70. The tread grooves 20 feature a chamfer 34 at the leading edge wall 24 to reduce or eliminate the catching of stones within the tread grooves 20. The chamfer 34 is visible in Fig. 2 and has a length 36. The tread groove 20 likewise has a length 30. The lengths 36 and 30 are the same such that the chamfer 34 extends along the entire length of the tread groove 20. However, other designs are possible in which the chamfer 34 extends less than the entire length 30 of the tread groove 20. However, in these other designs the length 36 of the chamfer 34 extends along at least a majority of the length 30 of the tread groove 20. In some embodiments, for example the embodiment illustrated with reference to Fig. 13, the chamfers 34 are intermittent along the length 30 of the tread groove 20. Here, a chamfer 34 extends along some of the length 30 and then ends while the tread groove 20 continues on until such time as another chamfer 34 is present in the tread groove 20. The length 36 is calculated by adding up all of the lengths 36 of the intermittent chamfers 34 and this length 36 is less than the length 30. There could be two, three, four, five, six, or more such intermittent chamfers 34 along the length 30 of the tread groove 20 in accordance with various exemplary embodiments.

[0029] The tread groove 20 has a component of extension in both the longitudinal direction 12 and the lateral direction 14 so that it is not oriented completely in the longitudinal direction 12 and not oriented completely in the lateral direction 14. The tread groove 20 is oriented at a groove angle 80 that in the Fig. 2 embodiment is 45 degrees. Groove angle 80 is measured by orienting the tread 10 with the rolling direction 18 pointing upward on the paper and locating a first point 82 of the tread groove 20 across its width. A tread centerline 86 is noted as running in the longitudinal direction 12 and located halfway across the tread 10 in the lateral direction 14. A second point 84 is located on the tread centerline 86 and is again halfway across the width of the tread groove 20. A straight line is drawn from the first point 82 to the second point 84, and this straight distance line 88 is 10 millimeters in distance. The selection of the location of points 82, 84 is constrained in that the points 82, 84 are not on the right hand side of the tread centerline 86 such that the closest second point 84 could be to the right hand side is on the tread centerline 86. The first point 82 thus will always be on the left hand side, while the second point 84 at most is on the tread centerline 86. The points 82, 84 could be selected to be any 10 millimeter straight distance line 88 from one another along the tread groove 20, and the distance 88 is a straight line distance. If the tread groove 20 is curved or angled, some amount of the straight distance line 88 may lay outside of the tread groove 20 when drawn,

[0030] A line is drawn through the first point 82 in the lateral direction 14. This line drawn through the first point 82 extends towards the tread centerline 86 from the first point 82. The groove angle 80 is then the angle measured between this line and the straight distance line 88. The groove angle 80 is measured only relative to the left hand side of the tread 10, relative to the rolling direction 18, because the tread 10 is a directional tread 10 and the right hand side of the tread 10 will generally be a mirror image of the left hand side and even if not will be arranged in a manner to make the tread 10 directional.

[0031] The groove angle 80 may be 45 degrees, may be 50 degrees, may be 30 degrees, may be greater than 30 degrees, greater than or equal to 35 degrees, greater than or equal to 40 degrees, greater than or equal to 45 degrees, greater than or equal to 50 degrees, greater than or equal 55 degrees, greater than or equal to 60 degrees, greater than or equal to 65 degrees, greater than or equal to 70 degrees, from 30 to 40 degrees, from 35 to 45 degrees, from 35 to 55 degrees, from 30 to 75 degrees, from 35 to 75 degrees, from 45 to 75 degrees, from 50 to 75 degrees, from 60 to 75 degrees, from 30 to 50 degrees, from 30 to 60 degrees, from 40 to 60 degrees, from 40 to 75 degrees, from 50 to 75 degrees, or greater than 30 degrees to less than or equal to 75 degrees in accordance with various exemplary embodiments. The groove angle 80 is thus an angle that shows some inclination of the tread groove 20 more than just a nominal amount as would be the case if a lateral groove of a tread 10 were slightly inclined or curved.

[0032] If the tread groove 20 is curved, the groove angle 80 can still be measured by drawing a line from the first point 82 to the second point 84 and this line may have one or more sections outside of the tread groove 20 due to its curvature. The other line is drawn in the lateral direction 14 through the first point 82, and the groove angle 80 can be measured between these lines. The groove angle 80 can be in the range as described above. If the tread groove 20 is made of multiple straight sections that are oriented at different angles, the same approach as previously described with respect to a curved tread groove 20 can be taken to measure the groove angle 80. Although the first point 82 is shown as being at the tread edge, it may be spaced anywhere inboard of the tread edge.

[0033] The selection of the location of points 82, 84 and the resulting straight distance line 88 may result in a groove angle 80 that does not fall within a desired range. However, the tread groove 20 is oriented so that at some location the points 82, 84 can be placed so that the straight distance line 88 is 10 millimeters with the resulting groove angle 80 falling within the designated range. As such, it is to be understood that the tread groove 20 need not be oriented so that every time the locations of points 82, 84 are selected the groove angle 80 is within the designated range. The tread groove 20 need only be set up so that at least one location of points 82, 84 the measured groove angle 80 falls within the designated range. In some embodiments, the points 82, 84 could be selected so that they are both within the tread groove 20 at locations of the tread groove 20 that do feature a chamfer 34.

[0034] In some embodiments, the entire tread groove 20 from the left hand tread edge 44 to the tread centerline 86 includes points 82, 84 that are 10 millimeters apart that feature the groove angle 80 within the desired range as discussed above. In these embodiments, you will find no points 82, 84 within the left hand tread edge 44 to tread centerline 86 zone establishing groove angles 80 that are outside of the desired range as discussed above.

[0035] Fig. 3 is a cross-sectional view taken along line 3-3 of Fig. 2 and shows both the leading edge wall 24 and the trailing edge wall 26. The leading edge wall 24 includes a bottom portion 32 and the chamfer 34. The bottom surface 28 extends from the bottom portion 32 to the trailing edge wall 26. The bottom portion 32 of the leading edge wall 24 extends from the bottom surface 28 to the chamfer 34, and the chamfer 34 in turn extends from the bottom portion 32 to the outer surface 22. The chamfer 34 has a particular orientation to the thickness direction 16. This orientation of the chamfer 34 relative to the thickness direction 16 remains constant along at least a portion of the length 36 of the chamfer 34. In other instances, it remains constant along at least a majority of the length 36 of the chamfer. Although the orientation of the chamfer 34 relative to the thickness direction 16 could change in some embodiments, it is at least constant along a portion of the length 36. This constant orientation of the chamfer 34 may be present in all versions of the tread 10 disclosed herein. In instances where the chamfer 34 does not extend along the entire length 30 of the groove 20, the chamfer 34 could be placed so that it is in the center of the tread 10 in the lateral direction 14 and not at the portions of the tread groove

20 that are proximate to or at the edges of the tread 10 at the tread edges 44, 70. The chamfers 34 need not be continuous along the entire length 30 of the tread groove 20, but could be intermittently disposed at constant or varying intervals along the length 30. Additionally or alternatively, the orientation angle 58 could be continuous along the entire length 30 of the tread groove 20, or may be varied at one or more points along the length 30 so that the orientation angle 58 is different at different points of the chamfer 34. If the chamfer 34 is intermittent, the orientation angle 58 could be the same for intermittent sections, or the intermittent sections could have different orientation angles 58, or different orientation angles 58 could be present at different points in each one of the intermittent chamfer 34 sections. It can be seen that the rolling direction 18 is shown in Fig. 3 even though this view is a cross-sectional view taken at an angle to the longitudinal direction 12. The rolling direction 18 shown in Fig. 3 is described as being a projection of the rolling direction onto the cutting plane of this cross-sectional view, and it is to be understood that this line represents only a component of the rolling direction 18 and that it is not the longitudinal direction 12.

[0036] The trailing edge wall 26 has an amount of extension 40 that is the length of extension of the trailing edge wall 26 from the bottom surface 28 to the outer surface 22. Depending upon the orientation of the trailing edge wall 26, the amount of extension 40 could be completely in the thickness direction 16 or may have components of extension in the thickness direction 16 and the longitudinal/lateral directions 12, 14. There is a fillet present between the trailing edge wall 26 and the bottom surface 28, and this fillet may be considered to be part of the trailing edge wall 26 and can be included in the measurement of the amount of extension 40. The leading edge wall 24 also has an amount of extension 38 that is composed of the amount of extension of the bottom portion 32 and the chamfer 34. The amount of extension 38 is not measured completely in the thickness direction 16, but only has a component of extension in the thickness direction 16. The bottom portion 32 and the bottom surface 28 have a fillet at their intersection, and this fillet could be counted as part of the bottom portion 32 for purposes of measurement of the amount of extension 38. The amount of extension 38 is measured from the flat portion of the bottom surface 28 along the fillet, along the bottom portion 32, and then along the chamfer 34 to the outer surface 22. The tread groove 20 is designed so that the amount of extension 38 is greater than the amount of extension 40. The entire tread 10 of the tire 68 can be arranged so that the leading edge wall 24 of the tread grooves 20 have chamfers 34, and so that none of the trailing edge walls 26 of the tread grooves 20 have chamfers 34. In this regard, all of the leading edge walls 24 of all of the tread grooves 20 found in all of the tread 10 can have chamfers 34 and all of the trailing edge walls 26 of all of the tread grooves 20 lack chamfers 34, or some but not all of the leading edge walls 24 of all of the tread grooves 20 have chamfers 34 while none of the trailing edge walls 26 have chamfers 34. It is therefore the case that embodiments exist in which there is not a single trailing edge wall 26 in any tread groove 20 of the entire tread 10 of the tire 68 that has a chamfer 34.

[0037] The chamfer 34 has an orientation relative to the thickness direction 16 that is different than the orientation of the bottom portion 32 to the thickness direction 16. In this regard, the leading edge wall 24 does not have a continuous orientation from the bottom surface 28 to the outer surface 22 but changes angles/orientation at some point. The trailing edge wall 26 has a sharp corner transition at the outer surface 22. However, in other arrangements a fillet or chamfer could be present at the intersection of the trailing edge wall 26 and the outer surface 22. If such feature were present at this location, the amount of extension 40 would still be less than the amount of extension 38. The face 48 of the chamfer 34 is flat, and this flat face 48 is flat all the way from the first intersection point 52 to the second intersection point 54. The first intersection point 52 is the point of engagement between the chamfer 34 and the bottom portion 32, and the second intersection point 54 is the point of engagement between the chamfer 34 and the outer surface 22. In some embodiments, all of the chamfers 34 in all of the tread grooves 20 in the entire tread 10 of the tire 68 have flat faces 48. In these embodiments, every leading edge wall 24 of every tread groove 20 of the entire tread 10 has a chamfer 34 with a flat face 48 or just a chamfer 34 with any configuration. In other embodiments, at least some, but not all, of the leading edge walls 24 of every tread groove 20 of the entire tread 10 has a chamfer 34 with a flat face 48 or a face 48 with any configuration.

[0038] The tread groove 20 as variously provided may have a certain geometry with respect to the chamfer 34 and sizes of the walls 24, 26 and bottom surface 28. An orientation line 56 extends in a straight line from the first intersection point 52 to the second intersection point 54. An orientation angle 58 is the angle from the thickness direction 16 to the orientation line 56. The thickness direction 16 could extend through the first intersection point 52, and the orientation angle 58 could be the smallest angle from this thickness direction 16 to the orientation line 56. The orientation angle 58 is greater than or equal to 20 degrees and less than or equal to 70 degrees. In other embodiments, the orientation angle 58 is greater than or equal to 30 degrees and is less than or equal to 60 degrees. In still other embodiments, the orientation angle 58 is greater than or equal to 40 degrees and is less than or equal to 50 degrees. The chamfer 34 need not have the same orientation angle 58 along its entire length 36. In some instances, the orientation angle 58 could be at one angle for a portion of the length 36, and then the orientation angle 58 could change to a different angle for the remainder of the length 36. In other instances, the orientation angle 58 may change ten or more times along the length 36 of the chamfer 34.

[0039] In addition to, or alternatively to, the aforementioned orientation angle 58 being within a particular range, the tread groove 20 may also include limitations relating to the edge walls 24, 26 and the bottom surface 28. The dimension of the tread groove 20 denoted as Wg which is reference number 60 is the maximum distance from the trailing edge wall 26 to the first intersection point 52 taken through the cross-sectional view of the tread groove 20 which is a 90 degree cut of the tread groove 20 along a portion of its length. The dimension of the tread groove 20 denoted as Hc in the figures, which is identified by reference number 62, is the height in the thickness direction 16 of the bottom portion 32. If there exists a fillet between the bottom surface 28 and the bottom portion 32, the length Hc 62 can be measured from the bottom surface 28 and thus include the length of this fillet in the thickness direction 16. The dimension of the tread groove 20 denoted as Dg which is element number 64 is the height of the trailing edge wall 26 in the thickness direction 16. If fillets are present at the intersection of the trailing edge wall 26 and the bottom surface 28, and at the intersection of the trailing edge wall 26 and the outer surface 22, then the dimension Dg 64 could be measured from the bottom surface 28 to the outer surface 22 in the thickness direction 16. In instances where the tread groove 20 includes features at the bottom surface 28, such as stone ejectors, then Dg 64 and Hc 62 are measured to the deepest portion of the tread groove 20 and not to the features included in the bottom surface 28 such as the stone ejectors.

[0040] The tread groove 20 may be arranged according to the following equation:

[0041] $Wg \leq Hc \leq (Dg - 2\ millimeters)$

[0042] It is to be understood that the range of orientation angle 58 and the equation respecting the Wg 60, Hc 62, and Dg 64 dimensions could both be present in some of the tread grooves 20, or neither of these could be present in other versions of the tread grooves 20, or one of these two criteria could be present in yet other versions of the tread grooves. In accordance with one exemplary embodiment, the equation respecting the Wg 60, Hc 62, and Dg 64 dimensions is present and Wg is 5 millimeters, Hc is 7 millimeters, and Dg is 10 millimeters. In this instance the equation is satisfied because 5 millimeters is less than 7 millimeters which is less than 8 millimeters.

[0043] Another example of the tread 10 design is shown in Fig. 4 in which the tread grooves 20 are arranged in a V-shape and extend completely from one of the tread edges 44 to the other tread edge 70. The chamfer 34 again has a length 36 that extends the entire length 30 of the tread groove 20, but as stated this need not be the case in other embodiments. A cross-sectional view of the tread groove 20 is shown in Fig. 5 and includes a chamfer 34 having an orientation different than that of the bottom portion 32. The tread groove 20 is different from previous versions in that the bottom portion 32 does not extend completely in the thickness direction 16 but instead has in addition to a component of extension in the thickness direction 16, components of extension also in the longitudinal/lateral directions 12, 14. The amount of extension 38 is measured from the bottom surface 28 not completely in the thickness direction 16 but instead at the same angle that the bottom portion 32 extends. The amount of extension 38 is then measured along the chamfer 34 to the outer surface 22. The orientation angle 58 is measured from the thickness direction 16 extending through the first intersection point 52 to the face 48, and is not measured from the angle the bottom portion 32 has to the thickness direction 16. The dimension Hc 62 is measured in the thickness direction 16 and not along the angle the bottom portion 32 makes with the thickness direction 16. The height Hc 62 of the bottom portion 32 can be continuous along the entire length 36 of the chamfer 34. Alternatively, the height Hc 62 could vary along the length 36. This variance could be constant so that the height Hc 62 may constantly vary as the chamfer 34 proceeds along its length 36. This variance could also be intermittent so that the height Hc 62 is the same along a portion of the length 36, and then change to a different height Hc 62 along a different portion of the length 36. The height Hc 62 could vary any degree any number of times along its length 36.

[0044] Another arrangement of the tread 10 is shown in Fig. 6 which includes again tread grooves 20 that extend in into both of the tread edges 44, 70. However, in other embodiments the tread grooves 20 need not extend into both of the tread edges 44, 70 or even into one of the tread edges 44 or 70. The tread 10 is again directional in that the tread grooves 20 are designed for forward movement of the tire 68. The tread 10 has a plurality of sipes 46 that extend some depth into the tread 10 from the outer surface 22. The sipes

46 are thin voids made into the tread 10 that have a width less than 2 millimeters. The sipes 46 extend into the chamfers 34 of the tread grooves 20, and in some arrangements extend into the bottom portion 32 of the tread grooves 20 as well. In this regard, the sipes 46 may engage both the chamfers 34 and the bottom portion 32 of the leading edge wall 24. The sipes 46 may likewise engage the trailing edge wall 26. Some of the sipes 46 engage the chamfer 34 but do not extend to the trailing edge wall 26, and other sipes 46 in the tread 10 engage the trailing edge wall 26 but do not engage the chamfer 34 or any other portion of the leading edge wall 24.

[0045] Fig. 7 is a cross-sectional view taken along line 7-7 of Fig. 6 and shows the cross-sectional shape of the tread grooves 20 of Fig. 6. The trailing edge wall 26 does not extend completely in the thickness direction 16 but instead is angled outward relative to the bottom portion 32. The amount of extension 40 is measured along the trailing edge wall 26 and is not measured completely in the thickness direction 16. The fillet between the bottom surface 28 and the trailing edge wall 26 can be considered to be part of the trailing edge wall 26 and may be included in the measurement of the amount of extension 40. The trailing edge wall 26 likewise includes a face 50 at its point of engagement with the outer surface 22, and this face 50 has a round and is not a sharp edge. This engagement location can be a round or can be a sharp edge in all of the various designs of the tread groove 20 disclosed herein. The height Dg 64 is measured from the bottom surface 28 to the top surface 22 and includes the heights of the round face 50 and the fillet at the bottom 28 along with the height of the trailing edge wall 26. Again, if features such as stone ejectors are present within the tread groove 20 then the height Dg 64 is measured to the deepest part of the tread groove 20 and not to this elevated feature. The leading edge wall 24 is designed as previously discussed and a repeat of this information is not necessary. The dimension Wg 60 is measured from the point where the round face 50 engages the outer surface 22 to the first intersection point 52. The length of the round face 50 is thus included in the measurement of the dimension Wg 60, and Wg 60 is a measurement of the farthest length of the trailing edge wall 26 to the first intersection point 52.

[0046] The description and the drawings describe and show different ways of measuring lengths such as the amounts of extension 38, 40. When the fillets and rounds, such as those associated with the bottom surface 28, bottom portion 32, trailing edge wall 24, and outer surface 22, are present they may or may not be included within the calculation of the amounts of extension 38, 40. In so far as the drawings show otherwise, the description of the inclusion or not inclusion of the fillets and rounds in these length measurements controls over any conflicting communication in the drawings.

[0047] Fig. 8 shows another alternate embodiment of the tread 10 with tread grooves 20 arranged into a generally V shape with ends that deviate from the V shape and engage both of the tread edges 44 and 70. Sipes 46 engage both the chamfers 34 and the trailing edge walls 26. The tread grooves 20 have a cross-sectional shape illustrated in Fig. 9 that is different from others shown herein in that the trailing edge wall 26 extends towards the leading edge wall 24 upon its extension away from the bottom surface 28. The leading edge wall 24 is arranged as others previously discussed. The trailing edge wall 26 has a fillet at its intersection with the bottom surface 28, and this fillet is considered to be part of the trailing edge wall 26. The amount of extension 40 is the length of this fillet and the length of the straight part of the trailing edge wall 26 up to the outer surface 22. The dimension Dg 64 is the height in the thickness direction 16 from the bottom surface 28 to the outer surface 22. The dimension Wg 60 is the length of the greatest distance from the trailing edge wall 26 to the first intersection point 52. This greatest distance is found at the bottom of the trailing edge wall 26 at the fillet between it and the bottom surface 28, since the rest of the trailing edge wall 26 extends towards the leading edge wall 24 from this point. Although differently designed cross-sectional shapes of the tread grooves 20 are shown with the different tread groove 20 patterns, it may be the case that a particular tread 10 has tread grooves 20 with different cross-sectional shapes and dimensions.

[0048] Fig. 10 shows an alternate embodiment of the tread groove 20 in which the chamfer 34 does not have a flat face but instead has a rounded, convex shaped face. The chamfer 34 can be variously configured in different arrangements and the shapes illustrated herein in the drawings are only exemplary. The round chamfer 34 engages the bottom portion 32 at the first intersection point 52, and engages the outer surface 22 at the second intersection point 54. The amount of extension 38 is measured in part along this curved, convex chamfer 34, with the rest being measured along the straight bottom portion 32 and the curved fillet between the straight bottom portion 32 and the bottom surface 28. The orientation line 56 of the chamfer 34 extends again through both the first and second intersection points 52, 54 and is arranged at the orientation angle 58 with the thickness direction 16. Again, the rolling direction 18 is illustrated in Fig. 10 but it is to be understood that this is not the longitudinal direction 12. The rolling direction 18 shown is a projection of the rolling direction 18 onto the cutting plane of the cross-sectional view of Fig. 10 as this view is not a cut-through of the lateral direction 14 or the longitudinal direction 12. This rolling direction 18 projection is also illustrated in previously described figures 5, 7 and 9 which are cross-sectional views that are taken at angles to the directions 12 and 14 and it is to be understood that the rolling direction 18 shown in Figures 5, 7 and 9 are not completely in the longitudinal direction 12 but just a component that can be displayed in those particular figures.

[0049] Although the tread groove 20 is shown as having a chamfer 34 at the leading edge wall 24 and no chamfer at the trailing edge wall 26, in other versions there may in fact be a chamfer at the trailing edge wall 26 in engagement with the outer surface 22. Placement of the chamfer 34 at the leading edge wall 24 provides a more efficient means to limit stone retention since it is this leading edge wall 24 of the tread groove 20 that encounters the stone as the tread 10 travels over the ground. Additionally, by having the diagonally oriented tread grooves 20, the action of the diagonal leading edge wall 24 as it rolls through the contact patch will limit the given stone's opportunity to drop into the tread groove 20. A diagonal tread groove 20, unlike a longitudinally oriented tread groove, does not provide the stone with a full opportunity to drop into the tread groove 20 during the entire period of contact. The trailing edge wall 26 is a boundary of the trailing edge of the rib and this diagonal trailing edge rib is in full contact with the ground, thus limiting the risk of abnormal wear. It is therefore the case that the tread groove 20 includes embodiments where there is no chamfer present at the intersection between the trialing edge wall 26 and the outer surface 22. This intersection could be a sharp edge, or could be a round that has a small radius of curvature. A sharp edge is present in the preferred embodiment, but need not be present in all embodiments.

[0050] Fig. 11 is a perspective view of the tread 10 in accordance with another exemplary embodiment in which another possible configuration of the chamfer 34 of the tread groove 20 is shown. It is to be understood that only a portion of the tread 10 is illustrated in Fig. 11 to show additional configurations of the chamfer 34. The tread groove 20 may be configured as previously discussed and a repeat of this information is not necessary. The chamfer 34 has several distinct portions along its length 36. A first portion 74 is present and has a width that changes a constant amount as the first portion 74 extends in its length 36 direction. As the width of the first portion 74 changes, the amount of extension 38 changes at different locations along the length of the first portion 74. As such, the amount of extension 38 is not constant along the entire length of the first portion 74 but is different at different locations. The width of the first portion 74, and hence the amount of extension 38, is greatest at a location closest to a second portion 76 of the chamfer 34. At all locations along the first portion 74, however, the amount of extension 38 is greater than the amount of extension 40. Although the width, and hence the amount of extension 38, changes along the first portion 74, it is the case that the orientation angle 58 of the first portion 74 remains the same along the entire first portion 74.

[0051] The chamfer 34 includes a second portion 76 immediately adjacent the first portion 74. The second portion 76 is arranged in a similar manner as the first portion 74 in that its width changes constantly along the length 36, and in that its orientation angle 58 remains the same at all points. The smallest width of the second portion 76 is adjacent the largest width of the first portion 74 and an offset in the chamfer 34 is present at this intersection. In turn, a third portion 78 is adjacent the second portion 76 and has a width that varies constantly along the length 36 and an orientation angle 58 that is constant at all points. The smallest width of the third portion 78 is adjacent the largest width of the second portion 76. The portions 74, 76, 78 are arranged so that they all have the same, constant orientation angle 58, and so that their widths are the same and their lengths are the same. However, in other embodiments, the widths of one or more of the portions 74, 76, 78 could be different than others, or the orientation angle 58 of one or more of the portions 74, 76, 78 could be different than others. Although three portions 74, 76, 78 are described, any number of portions could be present along the length 36 of the chamfer 34, and portions could be present along the entire length 36, a majority of the length 36, or a minority of the length 36.

[0052] Another version of the chamfer 34 is shown in Fig. 12 that is a perspective view of a portion of the tread 10 in another arrangement. The various features can be provided as previously discussed and a repeat of this information is not necessary. The chamfer 34 is provided in three different portions 74, 76, 78 and has a length 36. The first portion 74 has a face 48 and a constant orientation angle 58. Also, the width of the first portion 74 is constant along the entire length of the first portion 74, and the amount of extension 38 is the same at all points along the length of the first portion 74. The second portion 76 is adjacent the first portion 74 and has an orientation angle 58 that is constant along its entire length, but is different than the orientation angle 58 of the first portion 74. The second portion 76 has a face that is smaller than face 48. The amount of extension 38 of the second portion 76 is the same at all points along the length of the second portion 76.

However, the amount of extension 38 at the second portion 76 is different, in particular it is longer, than the amount of extension 38 at the first portion 74. This is because the length of the bottom portion 32 is longer before reaching the second portion 76 than that which reaches the first portion 74. The width of the second portion 76 is shorter than the width of the first portion 74, but the length of the bottom portion 32 at the second portion 76 makes the amount of extension 38 at the second portion 76 greater than that at the first portion 74. The amounts of extension 38 at the first portion 74 and the second portion 76 are still greater than the amount of extension 40.

[0053] The chamfer 34 has a third portion 78 that is contiguous with the second portion 76. The orientation angle 58 of the third portion 78 is the same as the orientation angle 58 of the first portion 74. The width of the third portion 78 is the same at all points along its entire length, and is the same width as that of the first portion 74. The third portion 78 is thus configured the same as that of the first portion 74. Although three portions 74, 76, 78 are shown, any number could be present in other embodiments. Also, they could alternate so that all of the odd numbered portions 74, 78 are arranged the same, and so that all of the even numbered portions 76 are arranged the same. The fact that the orientation angle 58 remains constant over the first portion 74 causes the orientation angle 58 of the chamfer 34 to remain constant over at least a portion of the length of the chamfer 34. Other variations of the tread groove 20 are possible so that the chamfer 34 is configured differently from that disclosed. In other embodiments, the orientation angles 58 of the first portion 74, second portion 76, and third portion 78 are all different from one another. If more than three portions are present in the chamfer 34, they may all be arranged so that their orientation angles 58 are different from one another.

[0054] While the present subject matter has been described in detail with respect to specific embodiments and methods thereof, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing may readily produce alterations to, variations of, and equivalents to such embodiments. Accordingly, the scope of the present disclosure is by way of example rather than by way of limitation, and the subject disclosure does not preclude inclusion of such modifications, variations and/or additions to the present subject matter as would be apparent.

CLAIMS

What is claimed is:

1. A heavy truck tire tread, comprising:

a longitudinal direction, a lateral direction, and a thickness direction, wherein the tread has a rolling direction that is in the longitudinal direction, wherein the tread has a tread centerline located halfway between edges of the tread in the lateral direction, wherein the tread is directional;

a tread groove that is not oriented completely in the longitudinal direction so as to extend in both the longitudinal direction and the lateral direction, wherein the tread groove extends in the thickness direction from an outer surface of the tread, wherein the tread groove is at least partially defined by a leading edge wall and a trailing edge wall and a bottom surface, wherein the tread groove has a length;

wherein a first point of the tread groove is located in the lateral direction on a left hand side of the tread centerline, wherein a second point of the tread groove is located on the left hand side of the tread centerline in the lateral direction or is located on the tread centerline, wherein the second point is located closer to the tread centerline than the first point in the lateral direction, wherein a straight distance line that is 10 millimeters in length extends from the first point to the second point, wherein a line extending in the lateral direction towards the tread centerline from the first point is oriented at a groove angle to the straight distance line, wherein the groove angle is greater than 30 degrees and is less than or equal to 75 degrees;

wherein the leading edge wall has a bottom portion and a chamfer, wherein the bottom portion extends from the bottom surface, wherein the chamfer extends from the bottom portion to the outer surface of the tread, wherein the chamfer has a length that extends along at least a portion of the length of the tread groove, wherein the bottom portion and the chamfer are oriented differently to one another relative to the thickness direction;

wherein an amount of extension from the bottom surface along the bottom portion and the chamfer to the outer surface is greater than an amount of extension from the bottom surface along the trailing edge wall to the outer surface;

wherein an orientation of the chamfer relative to the thickness direction remains constant along at least a portion of the length of the chamfer.

2. The tread as set forth in claim 1, wherein the length of the chamfer extends along the entire length of the tread groove such that the chamfer is continuous along the entire length of the tread groove.

3. The tread as set forth in claim 1 or 2, wherein the orientation angle of the chamfer relative to the thickness direction remains constant along the entire length of the chamfer such that the orientation angle of the chamfer relative to the thickness direction does not change along the entire length of the tread groove.

4. The tread as set forth in claim 1, wherein the chamfer is intermittent along the length of the tread groove such that the length of the chamfer is less than the length of the tread groove.

5. The tread as set forth in claim 1 or 4, wherein the orientation angle of the chamfer relative to the thickness direction is not the same along the entire length of the chamfer such that the orientation angle of the chamfer relative to the thickness direction changes at least at one point along the entire length of the tread groove.

6. The tread as set forth in any one of claims 1-5, wherein the trailing edge wall does not have a chamfer.

7. The tread as set forth in any one of claims 1-6, wherein the chamfer has a flat face.

8. The tread as set forth in any one of claims 1-6, wherein the chamfer has a rounded face.

9. The tread as set forth in any one of claims 1-8, wherein a round is present between the trailing edge and the outer surface of the tread.

10. The tread as set forth in any one of claims 1-9, wherein the trailing edge wall is parallel to the bottom portion of the leading edge wall.

11. The tread as set forth in any one of claims 1-9, wherein the trailing edge wall is not parallel to the bottom portion of the leading edge wall.

12. The tread as set forth in any one claims 1-11, wherein the bottom surface is parallel to the outer surface.

13. The tread as set forth in any one of claims 1-12, wherein a first intersection point is located at an engagement between the bottom portion and the chamfer, wherein a second intersection point is located at an engagement between the chamfer and the outer surface, wherein an orientation line extends through the first intersection point and the second intersection point, and wherein the orientation line is oriented at an orientation angle to the thickness direction, wherein the orientation angle is greater than or equal to 20 degrees and is less than or equal to 70 degrees.

14. The tread as set forth in any one of claims 1-13, wherein:

Wg is the greatest distance from the trailing edge wall to a first engagement point located at an engagement between the bottom portion and the chamfer;

Hc is the height in the thickness direction of the bottom portion;

Dg is the height in the thickness direction of the trailing edge wall;

wherein $Wg \leq Hc \leq (Dg - 2 \text{ millimeters})$.

15 The tread as set forth in any one of claims 1-14, wherein the chamfer has a first portion, a second portion, and a third portion, and wherein the orientation angle of the chamfer relative to the thickness direction remains constant along the first portion, the second portion, and the third portion, and wherein the first portion, the second portion and the third portion all have the same orientation angle of the chamfer relative to the thickness direction;

wherein the amount of extension from the bottom surface along the bottom portion and the first portion of the chamfer to the outer surface changes constantly along a length of the first portion of the chamfer;

wherein the amount of extension from the bottom surface along the bottom portion and the second portion of the chamfer to the outer surface changes constantly along a length of the second portion of the chamfer; and

wherein the amount of extension from the bottom surface along the bottom portion and the third portion of the chamfer to the outer surface changes constantly along a length of the third portion of the chamfer.

16. The tread as set forth in any one of claims 1-14, wherein the chamfer has a first portion, a second portion, and a third portion, and wherein the orientation angle of the chamfer relative to the thickness direction remains constant along the first portion, the second portion, and the third portion, wherein the first portion and the third portion have the same orientation angle of the chamfer relative to the thickness direction, and wherein the second portion has a different orientation angle of the chamfer relative to the thickness direction than the first portion and the third portions, and wherein the second portion is between the first portion and the third portion;

wherein the amount of extension from the bottom surface along the bottom portion and the first portion of the chamfer to the outer surface is the same along a length of the first portion of the chamfer;

wherein the amount of extension from the bottom surface along the bottom portion and the second portion of the chamfer to the outer surface is the same along a length of the second portion of the chamfer; and

wherein the amount of extension from the bottom surface along the bottom portion and the third portion of the chamfer to the outer surface is the same along a length of the third portion of the chamfer;

wherein the amount of extension from the bottom surface along the bottom portion and the first portion is the same as the amount of extension from the bottom surface along the bottom portion and the third portion;

wherein the amount of extension from the bottom surface along the bottom portion and the second portion is different than the amount of extension from the bottom surface along the bottom portion and the first portion.

17. The tread as set forth in any one of claims 1-16, wherein the groove angle is from 45 to 75 degrees.

18. The tread as set forth in claim 7, wherein the tread has a plurality of tread grooves that each have a leading edge wall and a trailing edge wall, wherein none of the trailing edge walls have chamfers such that none of the tread grooves of the entire tread have a chamfer, wherein chamfers are present on all of the leading edge walls and all have flat faces.

19. A heavy truck tire that has the tread of any one of claims 1-16.

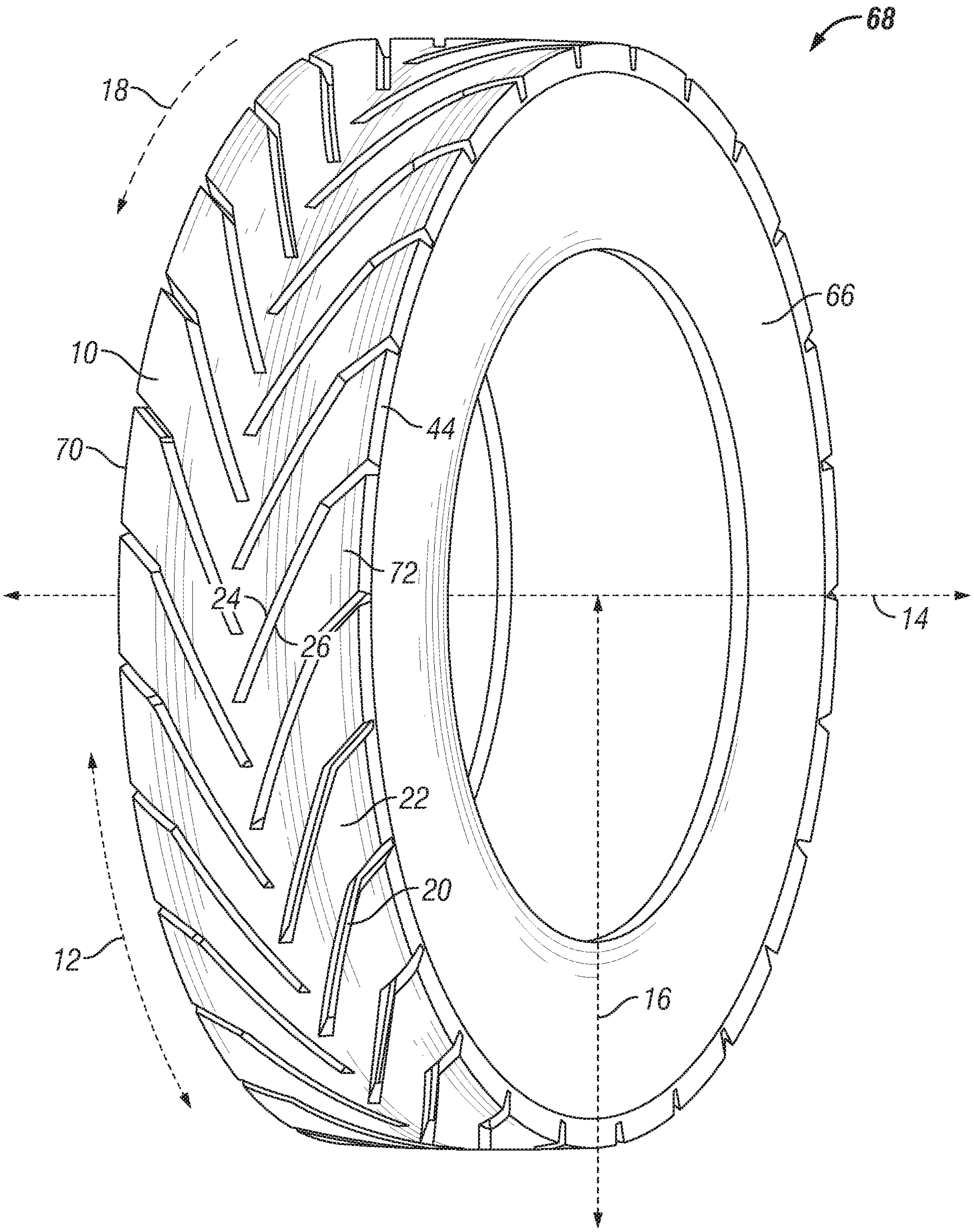

FIG. 1

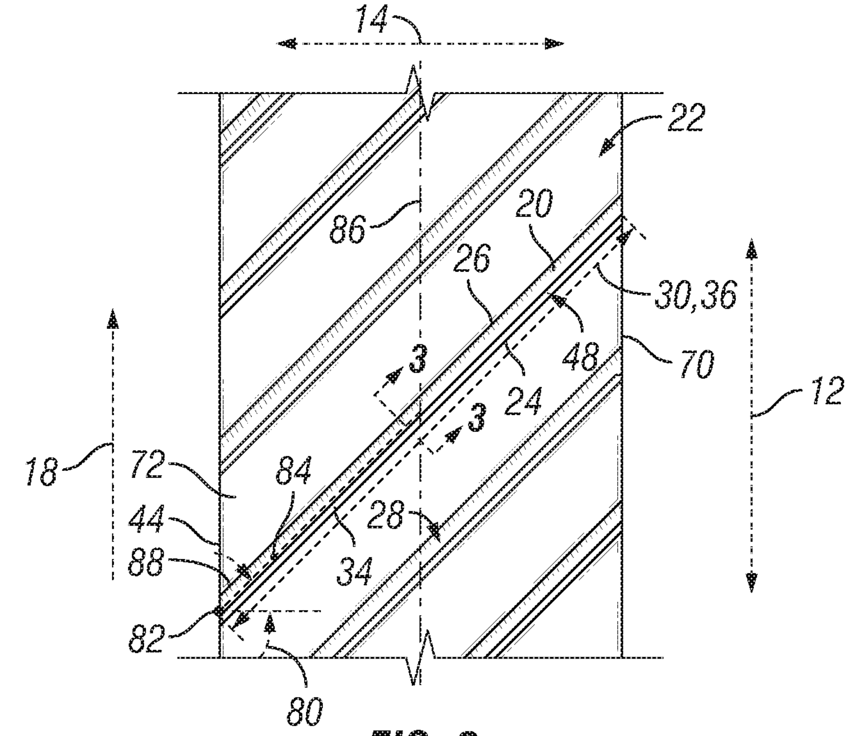
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FIG. 2

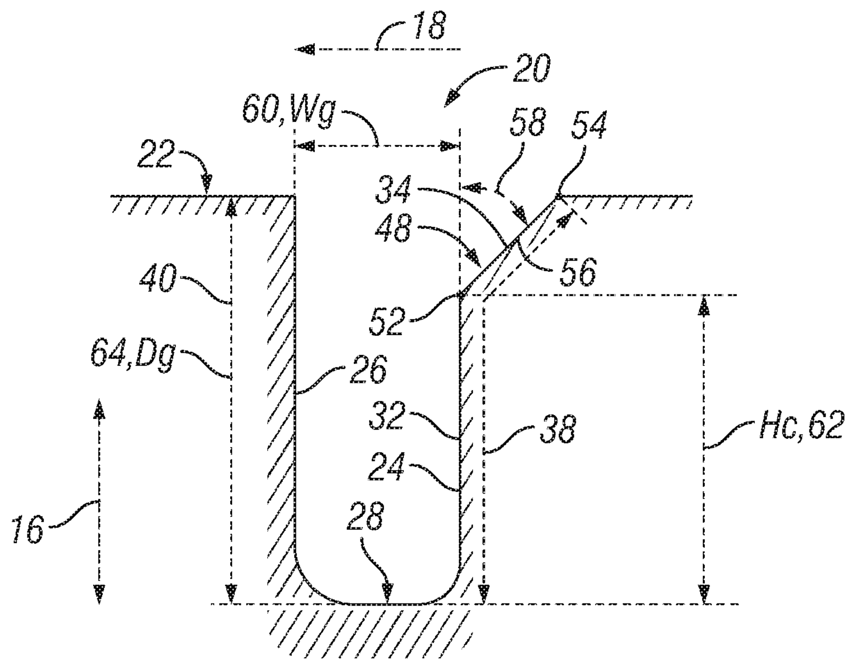
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FIG. 3

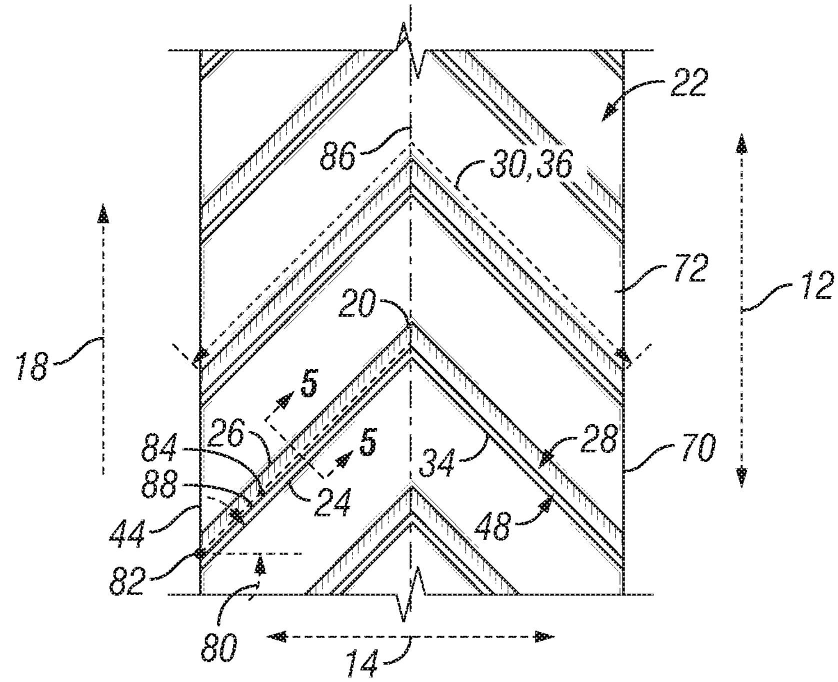
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FIG. 4

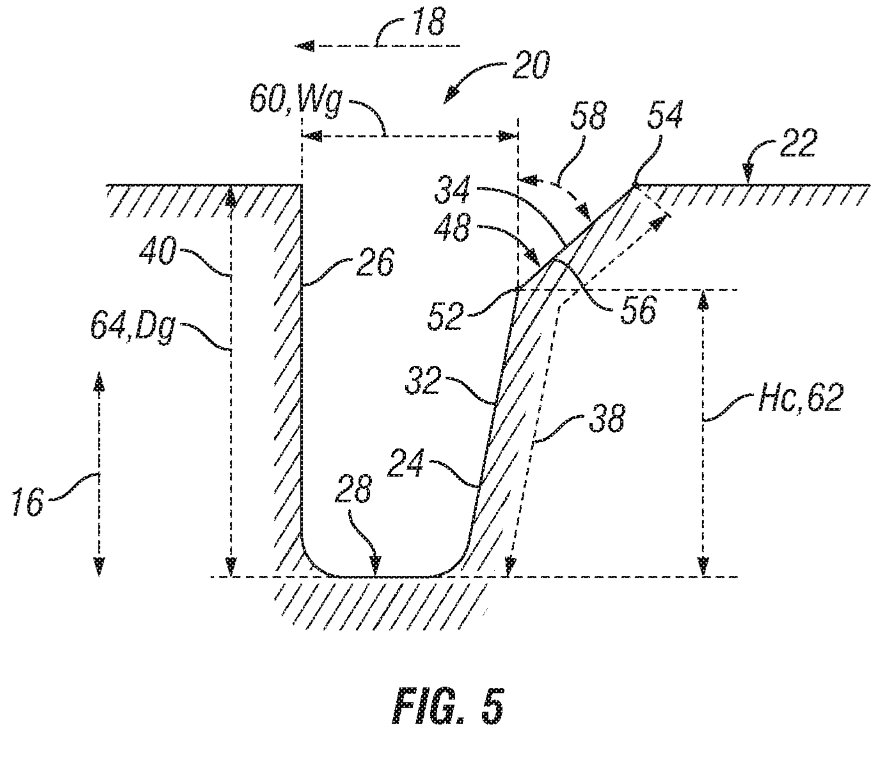
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FIG. 5

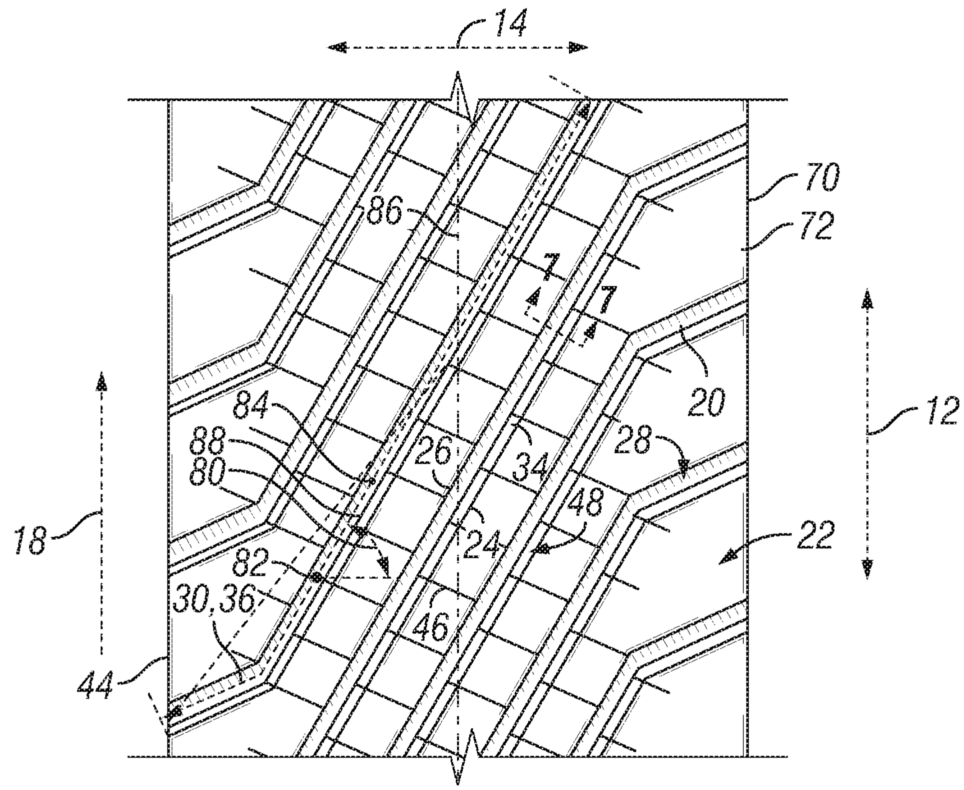
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FIG. 6

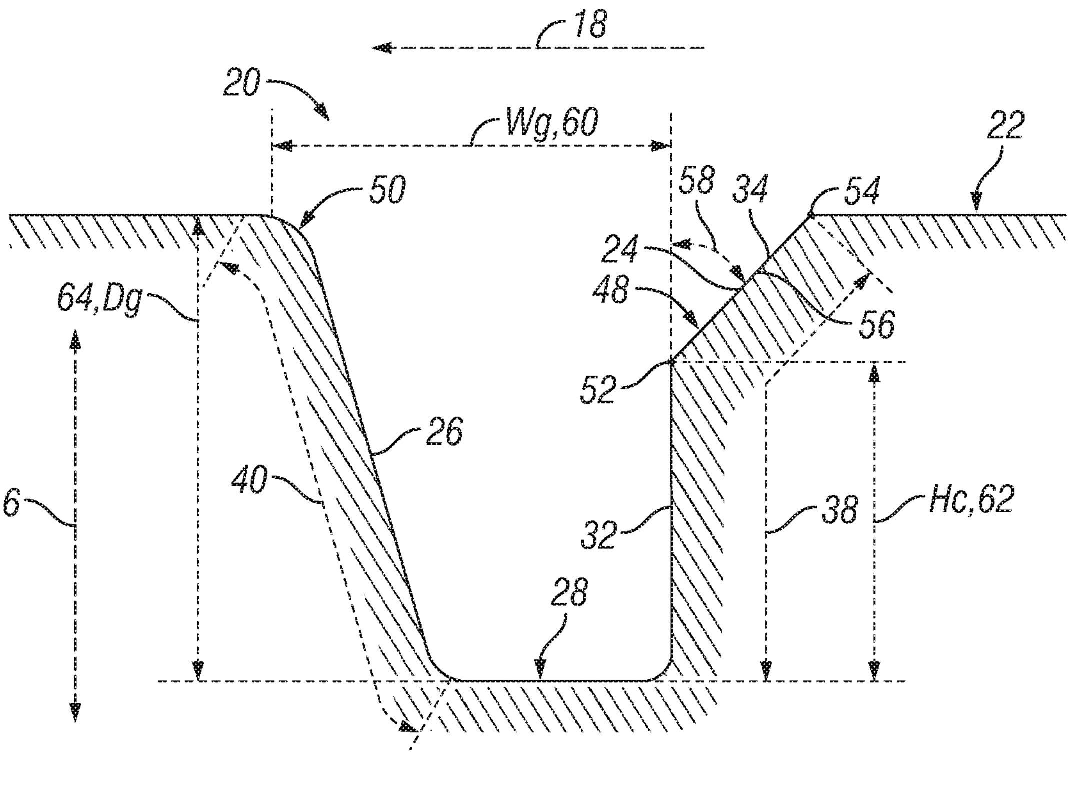
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FIG. 7

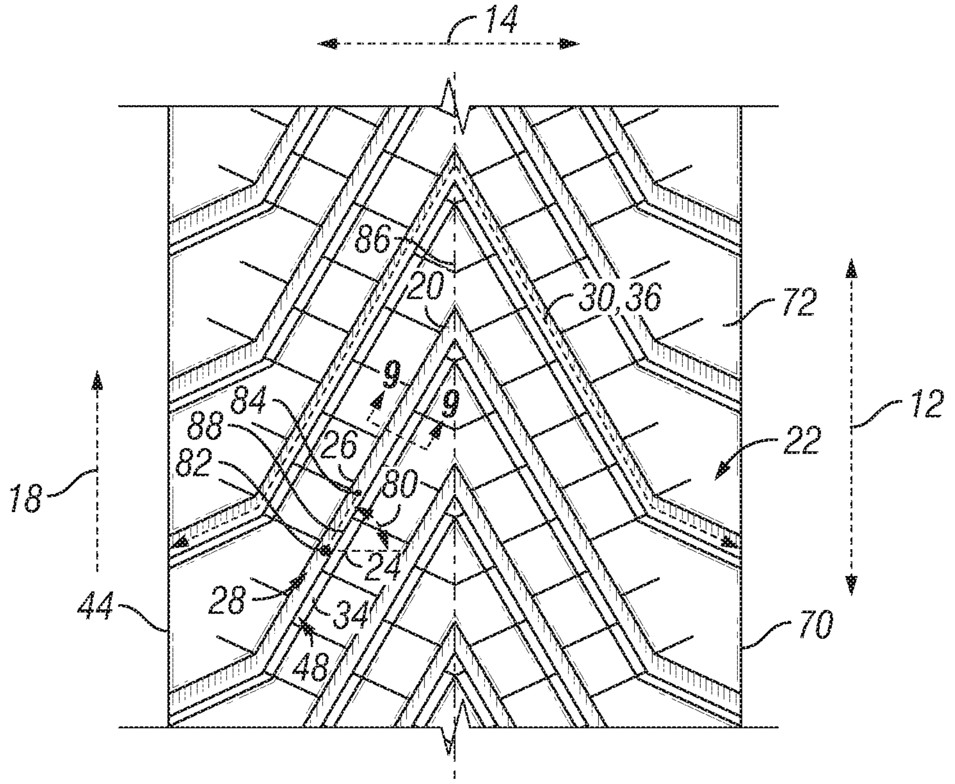
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FIG. 8

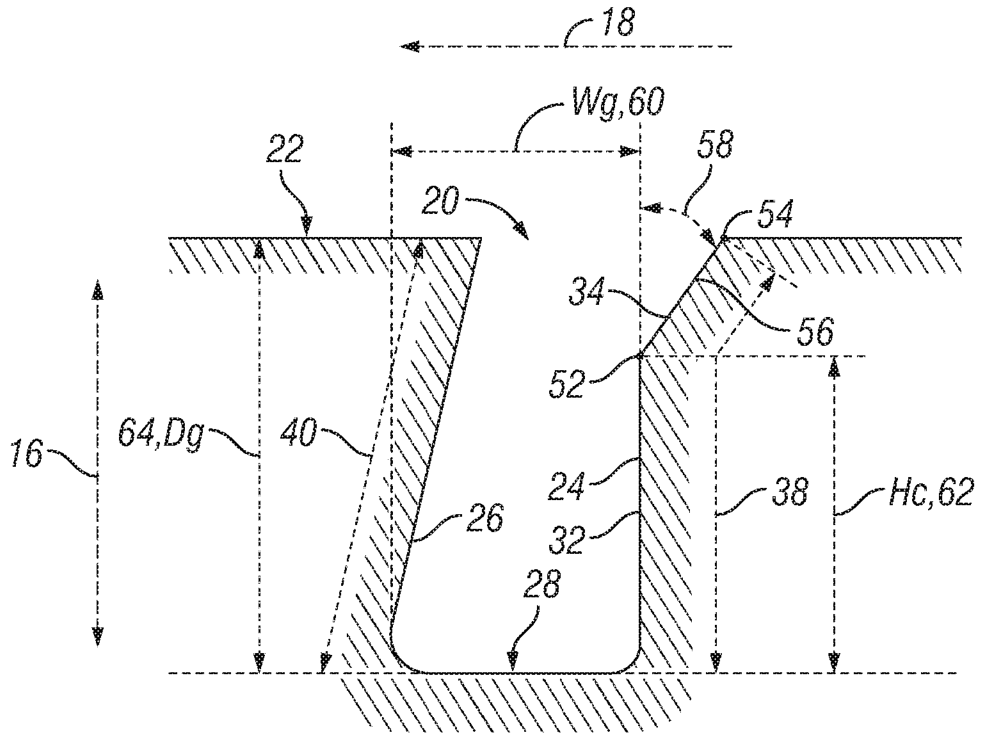
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FIG. 9

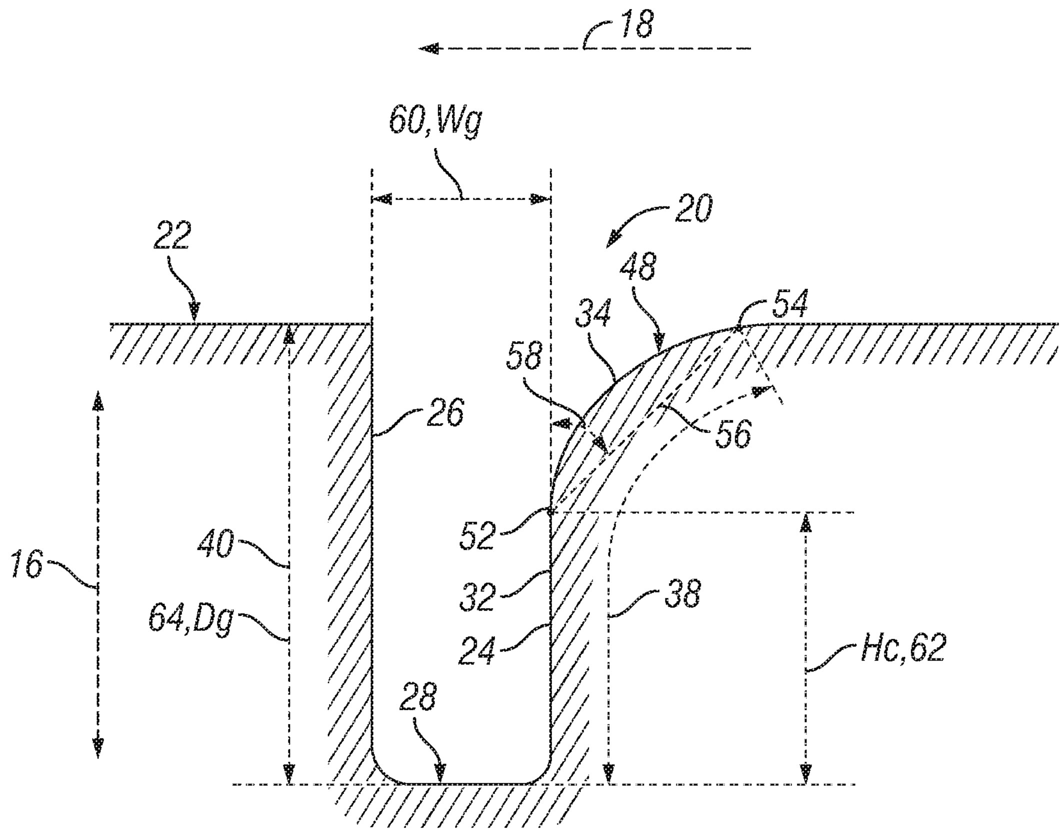

FIG. 10

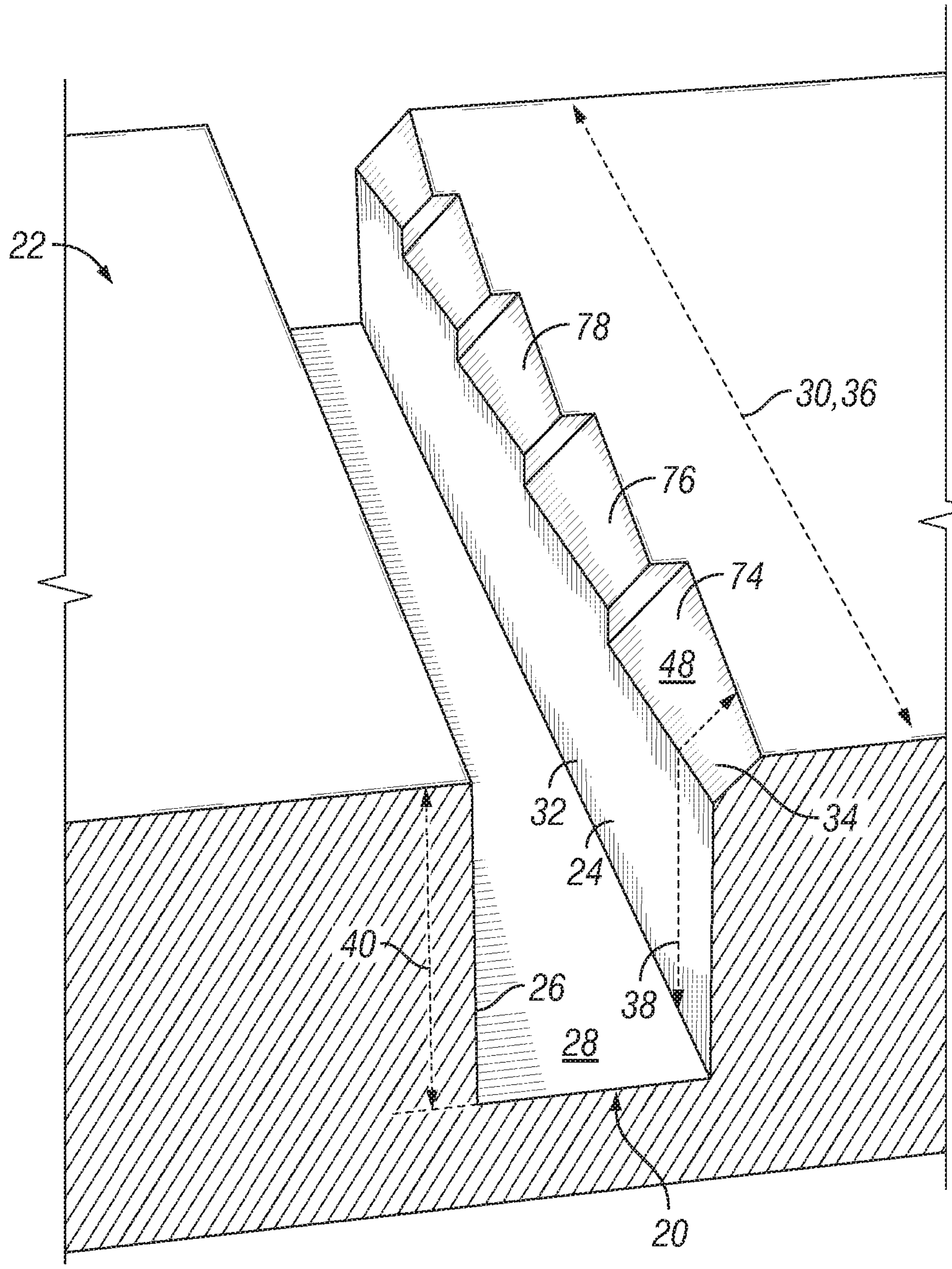

FIG. 11

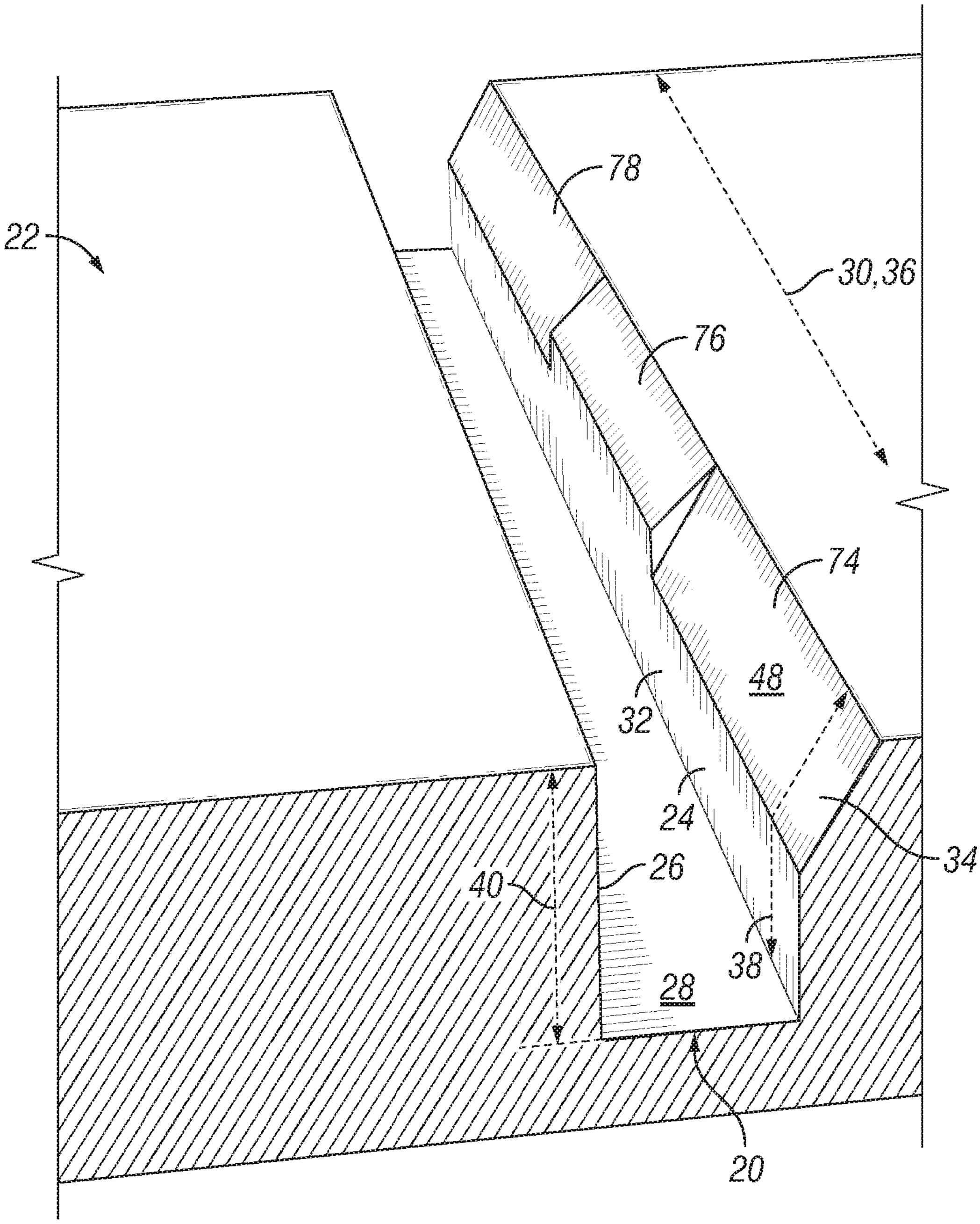

FIG. 12

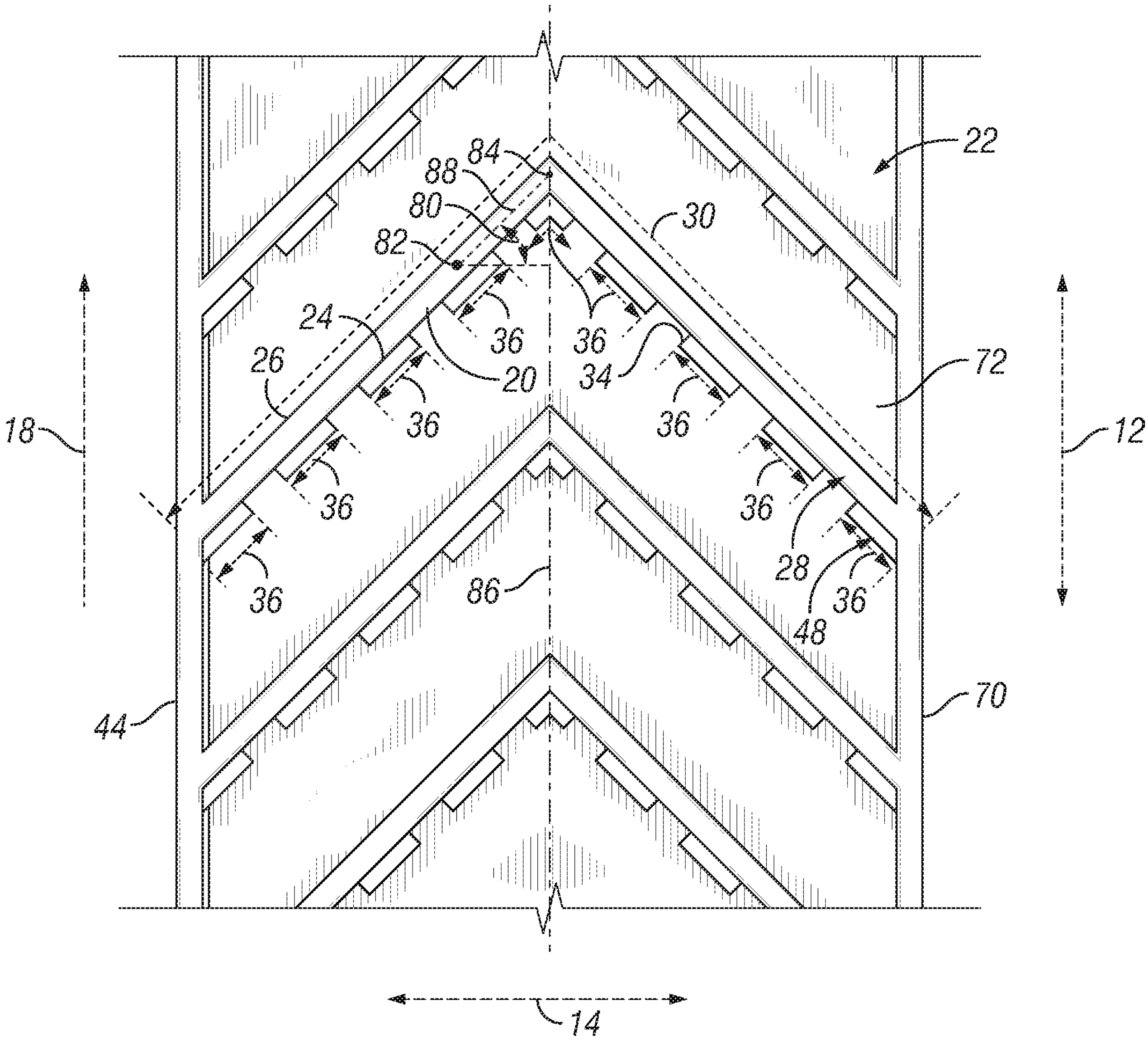
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FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/031273

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60C11/03 B60C11/13
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 479 973 A (IKEDA HIROMICHI [JP]) 2 January 1996 (1996-01-02)	1-3,6,7, 11-14, 17-19
Y	column 2, line 52 - column 5, line 18;	4,8,9
A	figures 1-3	5,10,15, 16

X	JP H11 301213 A (BRIDGESTONE CORP) 2 November 1999 (1999-11-02)	1-3, 6-10, 12-15, 17-19
A	figures	4,5,11, 16

Y	US 2012/067477 A1 (BERZINS MICHAEL A [US] ET AL) 22 March 2012 (2012-03-22)	8,9
A	paragraph [0026] - paragraph [0036]; figures 1-6	1,5,11, 15,16

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 June 2020	06/07/2020

Name and mailing address of the ISA/	Authorized officer
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International application No
PCT/US2020/031273

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