(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
05 July 2018 (05.07.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/125192 A1

(51) International Patent Classification:
B60C 7/10 (2006.01) *B60B 9/26* (2006.01)
B60B 1/04 (2006.01) *B60C 7/14* (2006.01)
B60B 9/04 (2006.01) *B60C 7/18* (2006.01)

(21) International Application Number:
PCT/US2016/069416

(22) International Filing Date:
30 December 2016 (30.12.2016)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,

(54) Title: MECHANICAL CONNECTION FOR SPOKE TO HUB ATTACHMENT FOR A NON-PNEUMATIC TIRE

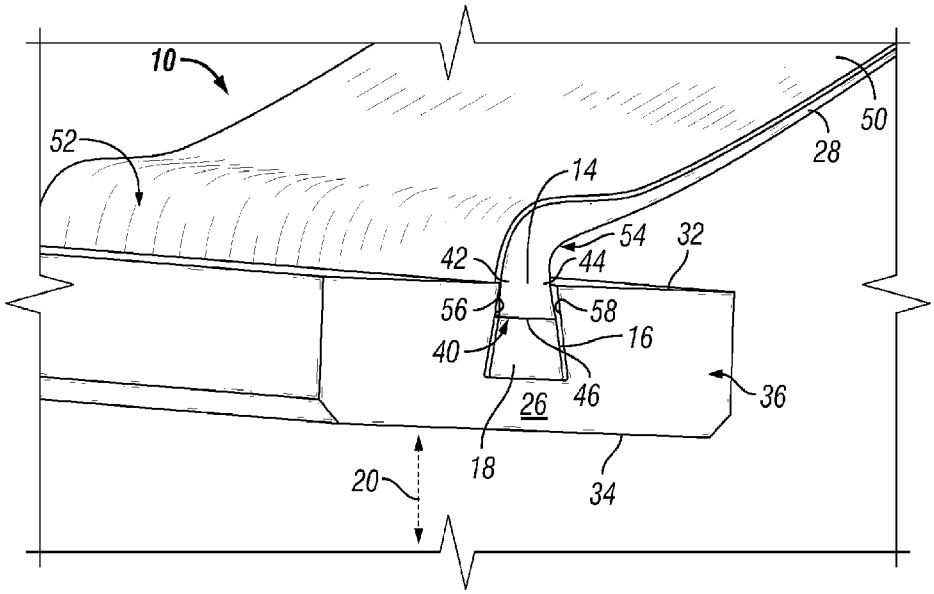


FIG. 12

(57) Abstract: A non-pneumatic tire is provided that has a shear band and a plurality of spokes (28) that extend in a radial direction from the shear band. A hub (26) that has a receiving feature (16) is present, and a spoke end (14) of the spoke (28) is disposed in the receiving feature (16). A key (18) is disposed in the receiving feature (16) and engages the spoke end 14) and holds the spoke end (14) in the receiving feature (16).

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MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

MECHANICAL CONNECTION FOR SPOKE TO HUB ATTACHMENT FOR A NON-PNEUMATIC TIRE

FIELD OF THE INVENTION

[0001] The subject matter of the present invention relates to an attachment mechanism for the production of non-pneumatic tires. More particularly, the present application involves a mechanical connection that attaches spokes of a non-pneumatic tire to a hub of the non-pneumatic tire.

BACKGROUND OF THE INVENTION

[0002] Non-pneumatic tires are those that do not require air. These tires instead feature a hub that is mounted onto a wheel of a vehicle, and a series of spokes that extend radially outward from the hub. The spokes can be attached to a shear band that includes tread of the tire. The spokes can be arranged and manufactured in a number of ways, and any number of spokes can be provided around the hub in the design of non-pneumatic tires.

[0003] One way of assembling a non-pneumatic tire involves placing components within a fixture and stretching the spokes to the hub through the use of an actuated device that causes the fixture to move to urge the spokes to the hub. Adhesive is applied to an inner surface of the shear band, or to the outer radial ends of the spokes. The actuated device holds the spokes against the hub for an amount of time required to cause connection through curing. This time may be from 10-30 minutes and ties up the fixture for this amount of time, and presents other challenges to the manufacturing process such as the application of the adhesive and the heating and pressure required to effect the connection.

[0004] Another way of attaching the spokes to the hub is through the use of a mechanical fastener, such as bolts and clamps, which can retain these components. The use of mechanical fasteners is time consuming, difficult to automate, and adds mass to the non-pneumatic tire. Further, the use of mechanical fasteners allows for fretting of the joint to occur which can damage the joint and possibly even cause failure. Due to the various manufacturing challenges associated with the production of non-pneumatic tires, a mechanism for addressing and improving upon issues associated with their production would be beneficial. As such, there remains room for variation and improvement within the art.

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 side view of a non-pneumatic tire.

[0007] Fig. 2 is a perspective view of a hub.

[0008] Fig. 3 is a top view of a hub.

[0009] Fig. 4 is a perspective view of a key.

[0010] Fig. 5 is an end view of a key.

[0011] Fig. 6 is a side view of the key of Fig. 5.

[0012] Fig. 7 is an end view of the key of Fig. 5.

[0013] Fig. 8 is a perspective view of a section of the non-pneumatic tire during assembly in a fixture.

[0014] Fig. 9 is a perspective view of a section of the non-pneumatic tire during assembly in the fixture from a different angle in Fig. 8.

[0015] Fig. 10 is a side view of a section of the non-pneumatic tire in which the spoke end is inserted into the receiving feature of the hub.

[0016] Fig. 11 is a side view of a section of the non-pneumatic tire in which a key is inserted into the receiving feature to retain the spoke end to the hub.

[0017] Fig. 12 is a perspective view of a section of the non-pneumatic tire in which the spoke is retained to the hub by a key.

[0018] The use of identical or similar reference numerals in different figures denotes identical or similar features.

DETAILED DESCRIPTION OF THE INVENTION

[0019] 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.

[0020] The present invention provides for a non-pneumatic tire 12 in which the connection between the spokes 28 and the hub 26 is made through the use of a key 18. The hub 26 can have a receiving feature 16, which in some instances could be a slot, that receives the

spoke end 14 of the spoke 28. The key 16 is used to attach the spoke end 14 to the hub 26. The key 16 could be inserted into the receiving feature 16, and an interference fit may be developed so that the spoke end 14 is retained within the receiving feature 16. This type of connection can be used on all of the spoke ends 14 of the spokes 28 to attach them all to the hub 26 in a similar fashion. The attachment of the spokes 28 to the hub 26 can be made so that no adhesive is needed or used to effect this attachment. The resulting connection may lack mechanical fasteners that would otherwise be subjected to fretting that could lead to degradation of the connection and possible failure.

[0021] A non-pneumatic tire 12 is illustrated with reference to Fig. 1 that includes a hub 26 that has a central axis 30. The radial direction 20 extends from the axis 30. Tread 98 is located on the outer exterior of a shear band 62 and extends all the way around the non-pneumatic tire 12 in the circumferential direction 22. The shear band 62 is located inward in the radial direction 20 from the tread 98 and likewise extends 360 degrees around the axis 30 in the circumferential direction 22. A series of spokes 28 engage the shear band 62 and extend inward in the radial direction 20 from the shear band 62 to the hub 26 of the non-pneumatic tire 12. Any number of spokes 28 can be present, and their cross-sectional shape can be different from that shown. In some embodiments, from 64-80 spokes 28 are present in the non-pneumatic tire 12. The spokes 28 can be connected to the shear band 62 in a number of manners. For instance, adhesive, mechanical fasteners, keys using interference fits, or any other mechanism can be used to attach the spokes 28 to the shear band 62, and in some instances these components 28 and 62 could be integrally formed with one another. The hub 26 is located inward from the spokes 28 in the radial direction 20 and can be mounted onto a wheel of the vehicle. The spokes 28 at the top of the non-pneumatic tire 12 are in tension, and the spokes 28 at the bottom are in compression as the non-pneumatic tire 12 rests on the ground 100 and as the non-pneumatic tire 12 turns in normal operation of the vehicle.

[0022] The spokes 28 are attached to the hub 26 by keys 18. In this regard, the hub 26 has a series of receiving features 16 into which spoke ends 14 of the spokes 28 are disposed. A key 18 is inserted into each one of the receiving features 16 and functions to lock the spoke end 14 into the receiving feature 16 to in turn attach the spoke 28 to the hub 26. The key 18 may effect attachment without the use of adhesives, and the resulting connection can have no parts that rub against one another to cause fretting as the key 18 is secured into the connection through the use of an interference fit.

[0023] The spokes 28 have a body 50 that has a V-shape so that the spokes 28 have a V-shape. Other shapes of the body 50 can be employed so that the spokes 28 have any other

desired shape, and multiple features can be present in the body 50 to provide additional functionality. The spokes 28 each have spoke ends 14 that are located at their radially inward ends in the radial direction 20. The spoke ends 14 may be integrally formed with the bodies 50 of the spokes 28.

[0024] The hub 26 is shown in perspective view in Fig. 2 in which an outer surface 32 of the hub 26 is the portion of the hub 26 farthest from the central axis 30 in the radial direction 20. An oppositely disposed inner surface 34 is closer to the central axis 30 in the radial direction 20 and with the outer surface 32 extends completely around the central axis 30 in the circumferential direction 22. A longitudinal direction 24 extends in the same direction as the central axis 30 and is parallel to the central axis 30. The hub 26 has a first longitudinal end surface 36 and an oppositely disposed second longitudinal end surface 38 that are spaced from one another in the longitudinal direction 24. The outer surface 32 extends completely from the first longitudinal end surface 36 to the second longitudinal end surface 38 in the longitudinal direction 24. The receiving features 16 are voids that extend form the outer surface 32 to an interior portion of the hub 26 but do not extend all the way to the inner surface 34. All of the receiving features 16 can be arranged in a manner similar to one another, and all may extend the same amount in the radial direction 20 inward from the outer surface 32 to the interior of the hub 26.

[0025] Fig. 3 is a top view of a hub 26 that is similar to that of Fig. 2, but features a smaller number of receiving features 16. However, the receiving features 16 are similar in design and again extend completely from the first longitudinal end surface 36 to the second longitudinal end surface 38 in the longitudinal direction 24, although that may not be the case in other arrangements as the receiving features 16 could only extend part of the way between surfaces 36 and 38. The receiving features 16 are slots that extend in the longitudinal direction 24 and are parallel to one another. The receiving features 16 can all be spaced the same distance from one another in the circumferential direction 22 about the outer surface 32, or they may be at different distances to one another in the circumferential direction 22. The receiving features 16 may all be open at the outer surface 32, at the first longitudinal end surface 36, and at the second longitudinal end surface 38.

[0026] The key 18 that is used in the attachment is shown in one exemplary embodiment in Fig. 4. The key 18 can have any cross-sectional shape, and as shown has a cross-sectional shape that has four side walls in which the top and bottom side walls are parallel, and in which the left and right side walls are angled toward one another. The side walls have rounds at their intersections. The key 18 extends in a longitudinal direction and maintains the same cross-sectional shape throughout its entire longitudinal length. Other designs of the key 18 are

possible, and Figs. 5-7 show one such variation. Here, the key 18 has a rectangular cross-sectional shape. In other versions, the cross-sectional shape of the key 18 could be square, triangular, circular, star shaped, oval, or any other shape. The key 18 may have a chamfered end 48 that is used to more easily insert the key 18 into the receiving feature 16 to effect connection. Only one end of the key 18 can be chamfered, or in other embodiments both of the ends could be chamfered. The chamfered end 48 may feature rounded corners that extend from the sides of the key 18 to the terminal end of the key that is flat.

[0027] In order to insert the spoke ends 14 into the receiving features 16, a fixture 10 as shown in Figs. 8 and 9 may be employed. The fixture 10 features a plurality of ramped elements 68 that extend in the circumferential direction 22 so that each spoke 28 is associated with one of the ramped elements 68. The hub 26 is positioned in the fixture 10, and the attached shear band 62 and spokes 28 are moved in the longitudinal direction 24 between the ramped elements 68, and as the spokes 28 engage the ramped elements 68 they are stretched inward in the radial direction 20 towards the central axis 18. The fixture 10 may also feature a plurality of guards 66 about the circumferential direction 22 so that each guard 66 is associated with one of the spokes 28. As the spokes 28 stretch and deform upon pressing contact with the ramped elements 68, the spoke ends 14 may likewise be displaced. The deflected, displaced spoke ends 14 are caught by the guards 66 and are prevented from being further deflected. As the spokes 28 continue to be pushed in the longitudinal direction 24, the spoke ends 14 are guided by the guards 66 into the receiving features 16. The spoke ends 14 enter into the receiving feature 16 through the opening in the first longitudinal end surface 36 and then slide through the entire receiving feature 16. The positioning of the spoke end 14 with respect to the hub 26 at the attachment location may be such that precision in the circumferential direction 22 and the longitudinal direction 24 is within plus or minus 0.2 millimeters to allow for good uniformity of the assembly. The attachment process compensates for variations in spoke 28 geometry. The fixture 10 illustrated in Figs. 8 and 9 stretches the spokes 28 and inserts them into the receiving features 16 of the hub 26 so that the spokes 28 are placed into pre-tension. The resulting non-pneumatic tire 12 that is constructed may thus be a tire 12 that features spokes 28 in pre-tension. However, this need not always be the case. In some exemplary embodiments, the ramped elements 68 are not present and the spoke ends 14 are simply slid into the receiving features 16 without any pre-tension being placed into the spokes 28. Although shown as employing a fixture 10 for inserting the spoke ends 28 into the receiving features 16, any type of device may be used to assemble these components of the non-pneumatic tire 12.

[0028] Fig. 10 shows one arrangement of the spoke end 14 that can be employed in the non-pneumatic tire 12. The spoke end 14 extends from the body 50 radially inward in the radial direction 20 and has a convex surface 52 and a concave surface 54 disposed from the convex surface 52 in the circumferential direction 22. A side wall 42 engages and extends from the convex surface 52, and a side wall 44 engages and extends from the concave surface 54. Additional surfaces could be between side wall 42 and convex surface 52 in other embodiments, and additional surfaces could be between side wall 44 and concave surface 54 in yet other arrangements. The side walls 42 and 44 are not parallel to one another but are angled to one another. The side walls 42, 44 can each be flat surfaces. The side walls 42 and 44 extend away from one another outward in the radial direction 20. The side walls 42, 44 terminate at a terminal end face 40 of the spoke end 14. The terminal end face 40 is the portion of the spoke 28 that is closest to the central axis 30 in the radial direction 20. The terminal end face 40 is shown as being a flat surface in the illustrated embodiment.

[0029] The spoke end 14 is inserted into the receiving feature 16 so that a portion of the spoke end 14 is within the receiving feature 16, and so that a portion of the spoke end 14 is not within the receiving feature 16. The receiving feature 16 has a cross-sectional shape that is similarly shaped to the spoke end 14 at the side walls 42, 44 and terminal end face 40. The receiving feature 16 is defined by a pair of side walls 56 and 58 that extend inward in the radial direction from the outer surface 32. The side walls 56, 58 diverge away from one another so that they are oriented at an angle to one another, and are not parallel to one another, and extend inward in the radial direction 20 so that they are farther form one another in their direction of extension inward in the radial direction 20. The bottom of the receiving feature 16 is flat, and the spoke end 14 upon insertion can be spaced a distance from the bottom of the receiving feature 16.

[0030] After the spoke end 14 is inserted into the receiving feature 16, the key 18 can be inserted into the receiving feature 16 to retain the spoke end 14 into the receiving feature 16 and thus cause the spoke 28 to be retained to the hub 26. If the key 18 has a chamfered end 48, the chamfered end 48 can be oriented so as to enter the receiving feature 16 first in order to facilitate entry of the key 18 into the receiving feature 16. The cross-sectional shape of the key 18 may resemble the cross-sectional shape of the void present in the receiving feature 16 after the spoke end 14 has been inserted into the receiving feature 16. In this regard, the cross-sectional shape of the key 18 may include a flat bottom, a flat top, and side walls that converge towards one another as they extend outward in the radial direction 20. The key 18 is sized, and in particular the cross-sectional shape of the key 18 is sized, so that it creates an interference fit upon insertion into the receiving feature 16 with the spoke end 14. Upon creation of this interference fit, the key 18

prevents the spoke end 28 from moving relative to the receiving feature 16, and the spoke end 28 is rigidly held within the receiving feature 16.

[0031] The key 18 is press fit into the connection so that the spoke end 28 is pushed slightly and urged outward in the radial direction 20. This outward urging in the radial direction 20 causes the side walls 42, 44 to engage the side walls 56, 58, and due to the length between the side walls 42, 44 in the circumferential direction 22 the spoke end 14 will not be able to be extracted from the receiving feature 16 in the radial direction 20. Fig. 11 shows the spoke end 14 pushed outward in the radial direction 20 from the position shown in Fig. 10. The side walls 42, 44 are urged against the side walls 56, 58 and the spoke end is locked into place within the receiving feature 16 and cannot move relative to the receiving feature 16 and the hub 26. Some of the side walls 42, 44 are located outside of the receiving feature 16 and thus do not engage the hub 26, but in other arrangements it is the case that all of the side walls 42, 44 engage the hub 26 and are located within the receiving feature 16.

[0032] The key 18 may completely fill the void of the receiving feature 16 such that the entire receiving feature 16 is filled up by the key 18 and some of the spoke end 14. In other embodiments, this may not be the case and instead one or more voids of the receiving feature 16 are still present even after the key 18 has been inserted and the spoke end 14 is locked to the hub 26. The key 18 can create an interference fit at location 46 that is the point of engagement between the key 18 and the terminal end face 40. Other faces of the key 18 may not have an interference fit, such as faces on the left and right circumferential sides. The interference fit is a tight engagement between parts in which one or both of them are compressed somewhat to create a high frictional engagement that cannot be disengaged without an extreme amount of force. The insertion of the key 18 may take place in the fixture 10 shown in Figs. 8 and 9 when the spoke end 14 is inserted into the receiving feature 16, or the insertion of the key 18 may take place after the non-pneumatic tire 12 has the spoke ends 14 inserted and the non-pneumatic tire 12 is removed from the fixture 10 and moved to a different location. Once the keys 18 are inserted, they are fixed and cannot be removed absent the application of high forces that are intentionally and specifically applied. This form of attachment allows the hub 26 to be removed from the spokes 28 at a later time if desired for replacement of one or more of these components or for any other desired reason. The connection of the spoke ends 14 to the hub 26 through interference fits with the key 18 can be achieved without the use of adhesive.

[0033] Another embodiment of the connection interface is illustrated with reference to Fig. 12 in which the key 18 is again inserted into the receiving feature 16, and the spoke end 14 is again present within the receiving feature 16 and held therein by the key 18. The key 18 and

terminal end face 40 are engaged with one another via an interference fit at location 46. The inward most end of the key 18 in the radial direction 20 engages the hub 26 and may or may not form an interference fit at this location. Some voids are present between the key 18 and the side walls 56, 58 of the receiving feature 16 in the circumferential direction 22 and are located inward from the spoke end 14 in the radial direction 20. As such, the key 18 does not completely fill the void of the receiving feature 16. The key 18, hub 26, and spoke 28 may thus be separate pieces from one another that are first formed, and then subsequently attached to one another so that they are not integrally formed with one another. The interference fit formed that attaches the spoke end 14 to the hub 26 may eliminate the problem of fretting that would otherwise occur with a bracketed or bolted connection. The key 18 may be driven into place between the spoke end 14 and the hub 26 by the use of a hydraulic or pneumatic mechanism. The spoke end 14 may be held with sufficient preload to prevent it from moving within the joint, and the interference fit keeps the spoke end 14 from moving within the joint.

[0034] The key 18 may thus be located between the terminal end face 40 and the hub 26 so that the key 18 is located completely inward from the terminal end face 40 in the radial direction 20. The key 18 can be variously shaped and sized, and it is to be understood that the shapes and sizes shown are only exemplary. Further, although disclosed as being located completely within the receiving feature 16, in some embodiments, the key 18 or a portion of the key 18 may extend outward in the radial direction 20 so that it is outside of the receiving feature 16 and outward from the hub 26 in the radial direction 20. All of the keys 18 of the non-pneumatic tire 12 may be simultaneously driven into the plurality of receiving features 16, or they may be driven in one at a time, or any block or combination could be driven in various embodiments.

[0035] 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 readily apparent to one of ordinary skill in the art.

WHAT IS CLAIMED IS:

1. A non-pneumatic tire, comprising:

a shear band;

a plurality of spokes that extend in a radial direction from the shear band, wherein one of the spokes has a spoke end;

a hub that has a receiving feature, wherein the spoke end is disposed in the receiving feature, wherein the hub has a central axis; and

a key that is disposed in the receiving feature that engages the spoke end, wherein the key holds the spoke end in the receiving feature.

2. The non-pneumatic tire as set forth in claim 1, wherein the spoke end is held in the receiving feature without adhesion.

3. The non-pneumatic tire as set forth in claim 1 or 2, wherein the hub has an outer surface, and wherein the receiving feature extends radially inward from the outer surface to an interior of the hub, wherein the receiving feature does not extend to an inner surface of the hub.

4. The non-pneumatic tire as set forth in any one of claims 1-3, wherein the hub has a longitudinal end surface, and wherein the receiving feature extends in a longitudinal direction from the longitudinal end surface to the interior of the hub.

5. The non-pneumatic tire as set forth in any one of claims 1-4, wherein the spoke end has a terminal end face, and wherein the terminal end face is disposed in the receiving feature, and wherein a portion of the spoke end is disposed in the receiving feature but not all of the spoke end is disposed in the receiving feature.

6. The non-pneumatic tire as set forth in any one of claims 1-5, wherein the receiving feature is defined by side walls that are straight and extend in the radial direction, longitudinal direction, and circumferential direction;

wherein the receiving feature increases in size inward in the radial direction;

wherein the spoke end has side walls that are straight and extend in the radial direction, longitudinal direction, and circumferential direction; and

wherein the spoke end increases in size inward in the radial direction.

7. The non-pneumatic tire as set forth in any one of claims 1-6, wherein the entire key is located closer to the central axis than the spoke end in the radial direction.

8. The non-pneumatic tire as set forth in any one of claims 1-7, wherein the shear band, the plurality of spokes, the hub, and the key are all separate components from one another and are not integrally formed with one another.

9. The non-pneumatic tire as set forth in any one of claims 1-8, wherein the receiving feature is a void that is completely filled by the spoke end and the key such that there is no empty space remaining within the receiving feature.

10. The non-pneumatic tire as set forth in any one of claims 1-9, wherein the key attaches the spoke end to the hub by an interference fit.

11. The non-pneumatic tire as set forth in any one of claims 1-10, wherein an interference fit is present between the key and the terminal end face of the spoke end.

12. The non-pneumatic tire as set forth in any one of claims 1-11, wherein the key has a chamfered end, wherein the chamfered end of the key is oriented to face in a longitudinal direction and is not oriented to face the central axis.

13. The non-pneumatic tire as set forth in any one of claims 1-12, wherein the spoke has a body, and wherein the spoke end has a convex surface and a concave surface, wherein the spoke body has a V-shape;

and wherein the receiving feature is a slot that extends from the longitudinal end surface of the hub, that is a first longitudinal end surface, to an oppositely disposed second longitudinal end surface of the hub such that the receiving feature is open on both the first and second longitudinal ends of the hub, wherein the receiving feature is open on the outer surface of the hub, wherein the outer surface of the hub extends from the first longitudinal end surface to the second longitudinal end surface.

14. The non-pneumatic tire as set forth in any one of the preceding claims, wherein all of the spokes of the plurality of spokes have spokes ends, wherein the hub has a plurality of the

receiving features, and wherein a plurality of the keys are present, wherein all of the spokes are disposed into the receiving features, and wherein the keys are disposed into the receiving features and retain the spoke ends into the receiving features.

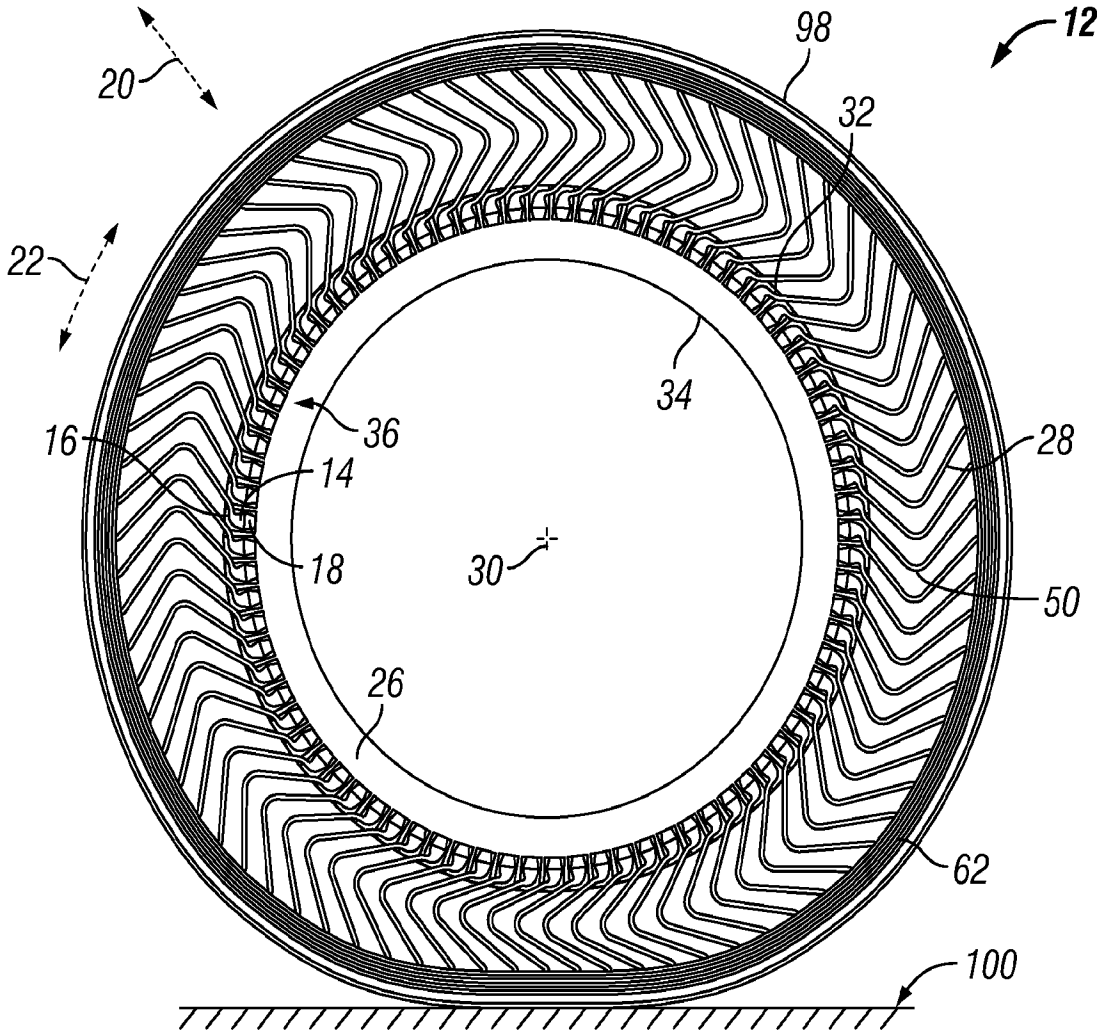


FIG. 1

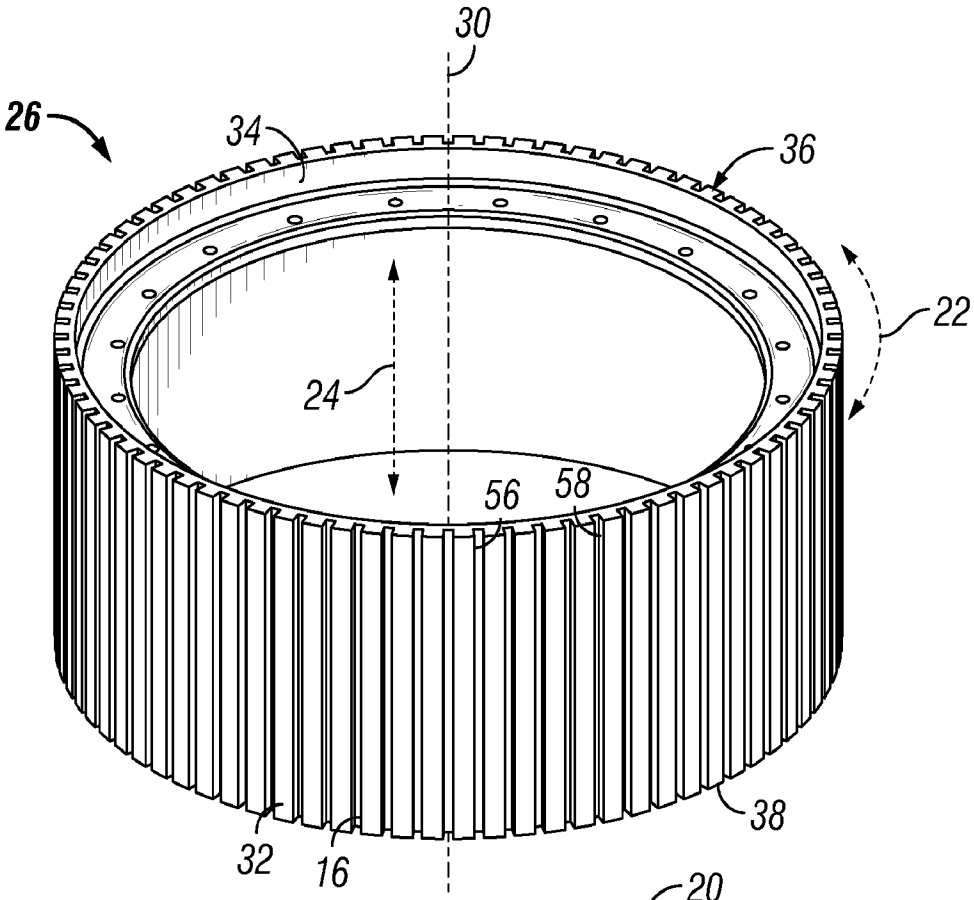


FIG. 2

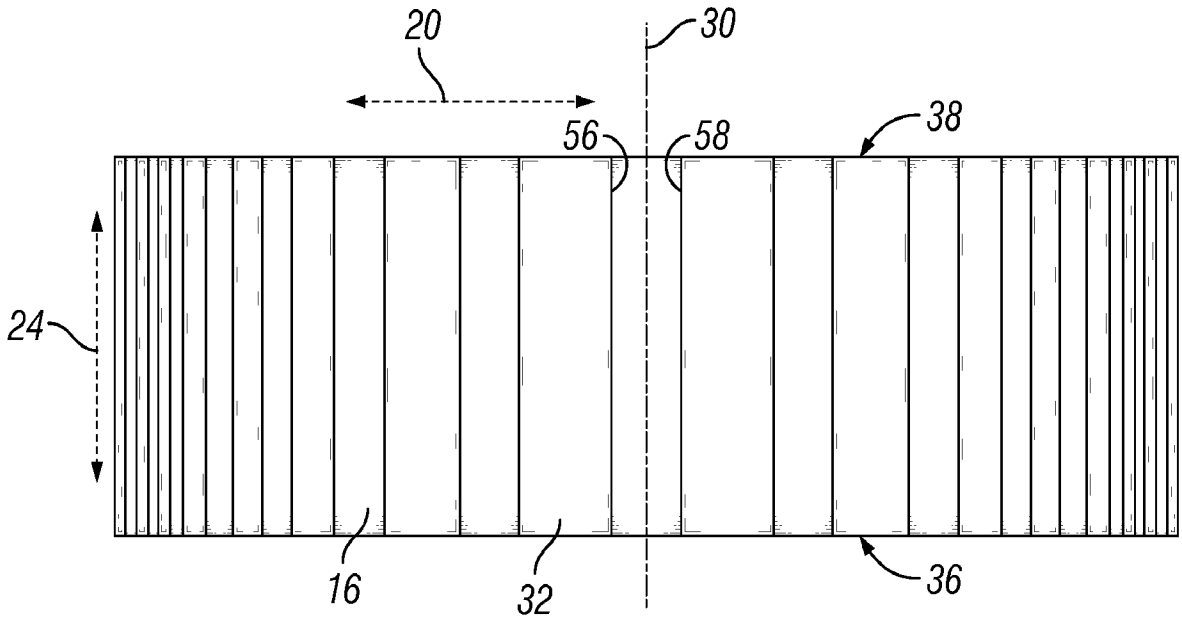


FIG. 3

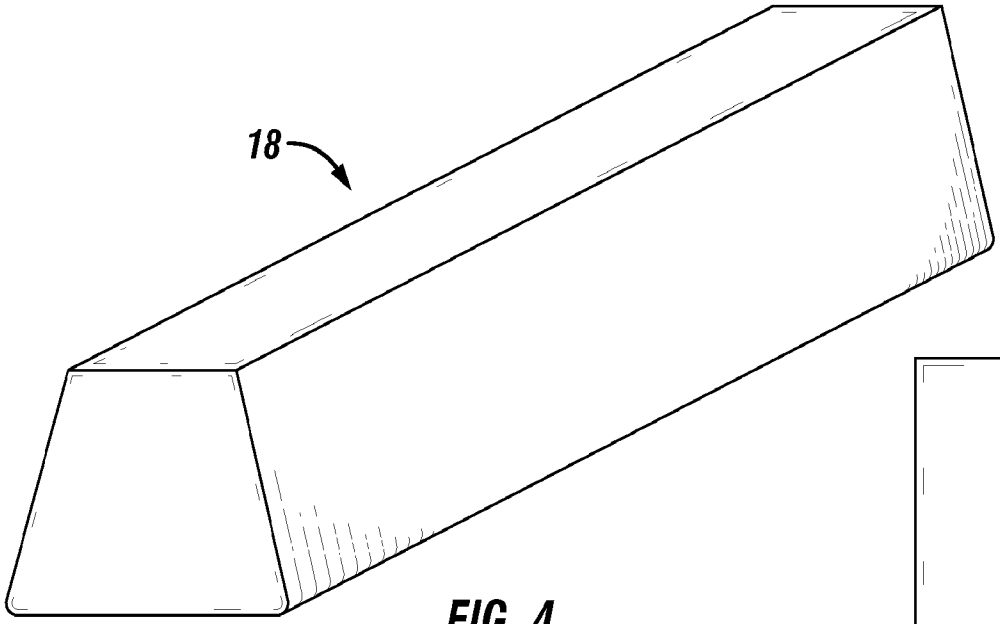


FIG. 4

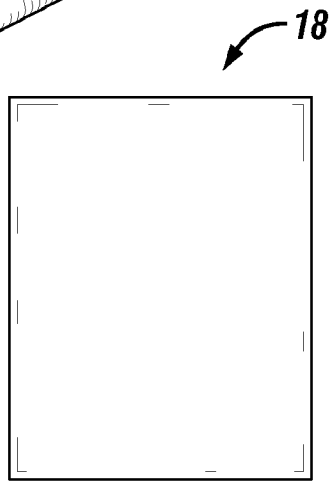


FIG. 5

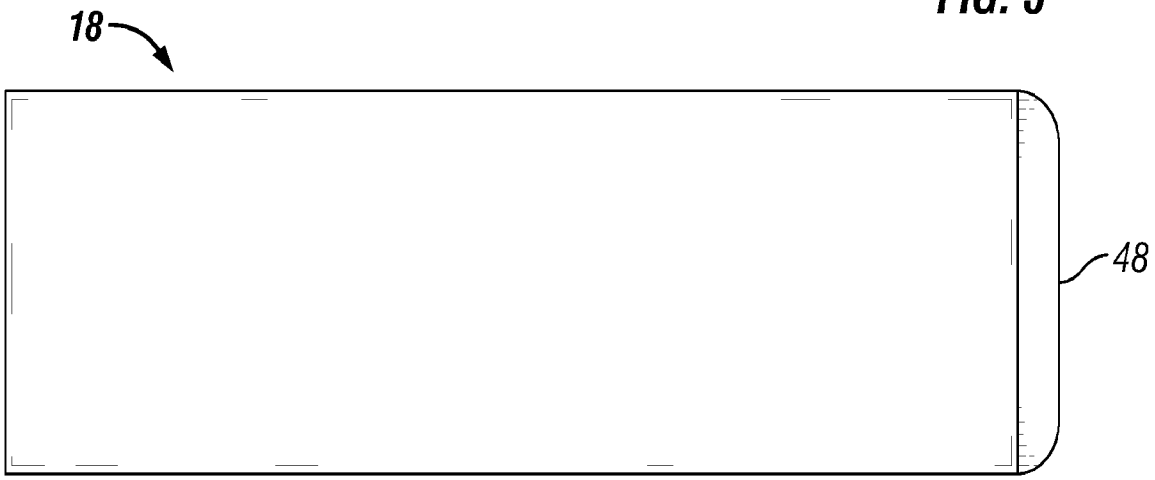


FIG. 6

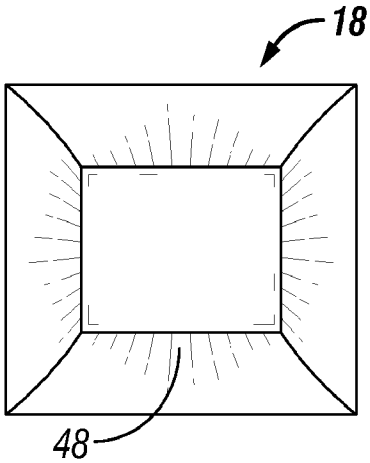


FIG. 7

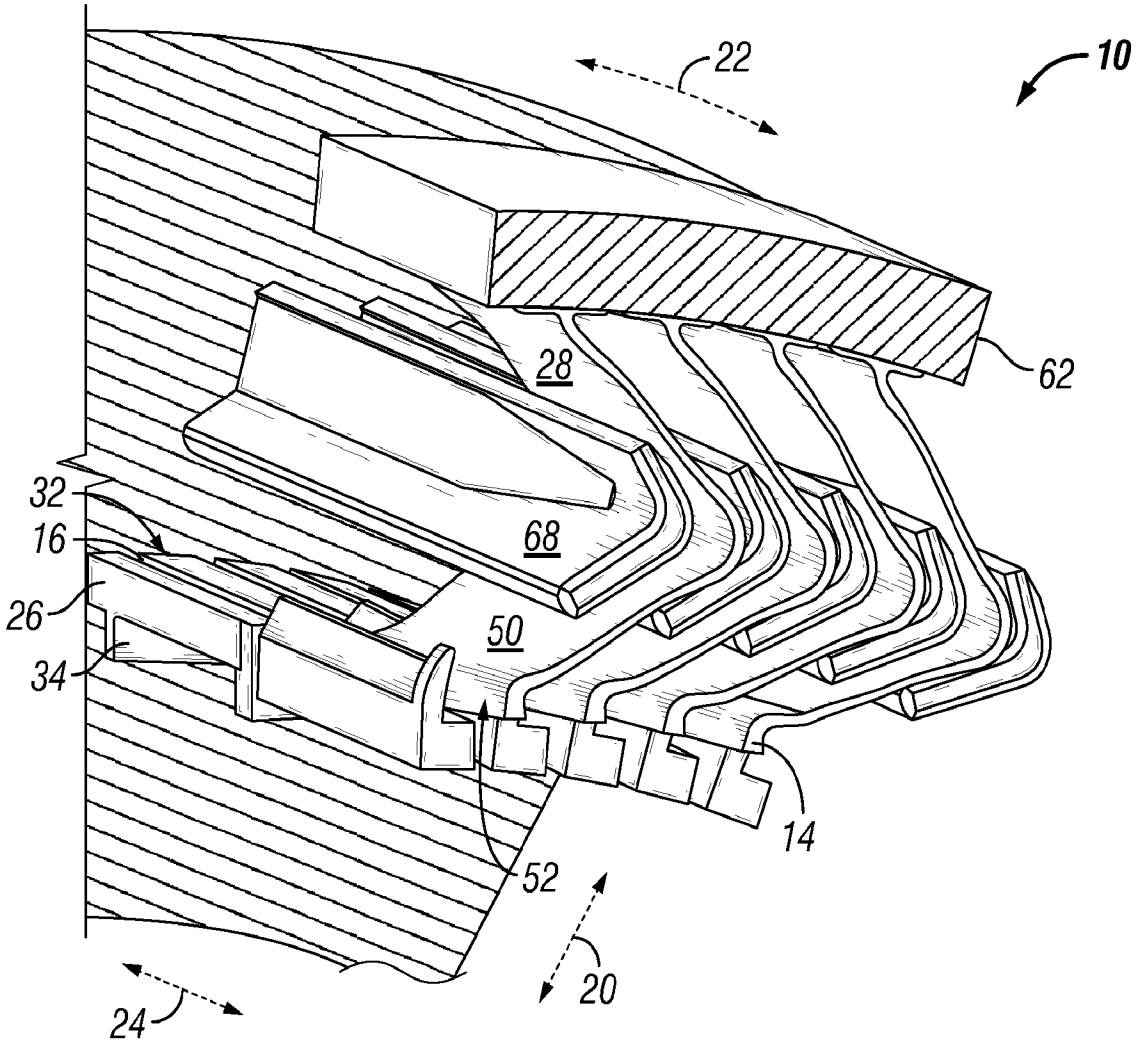


FIG. 8

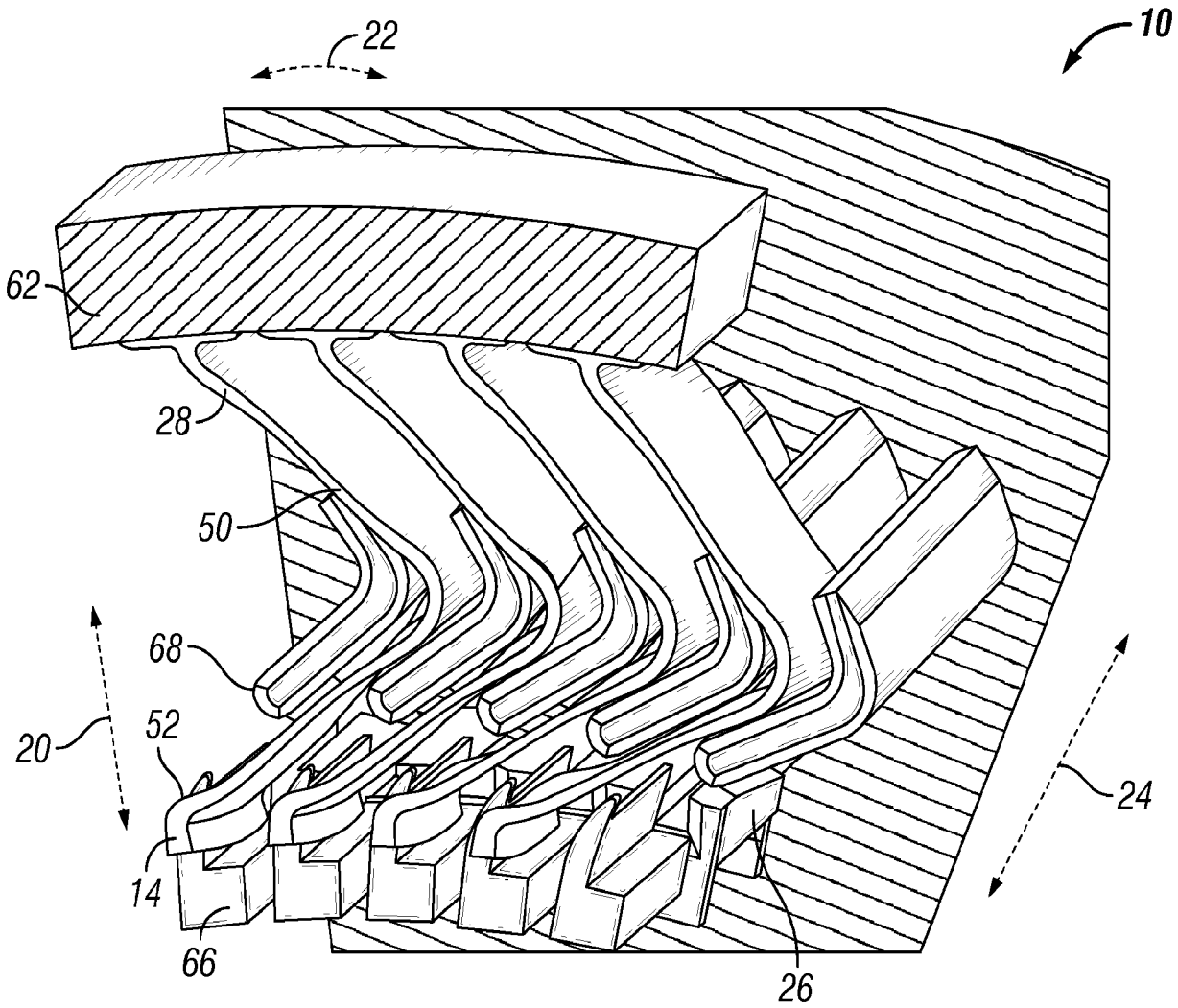


FIG. 9

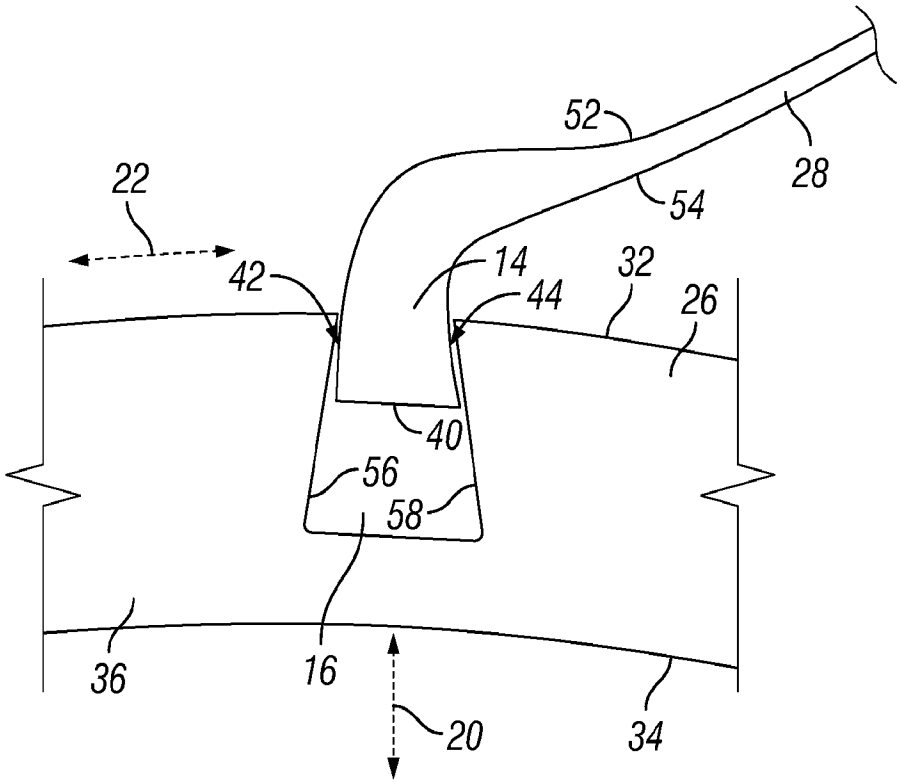

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FIG. 10

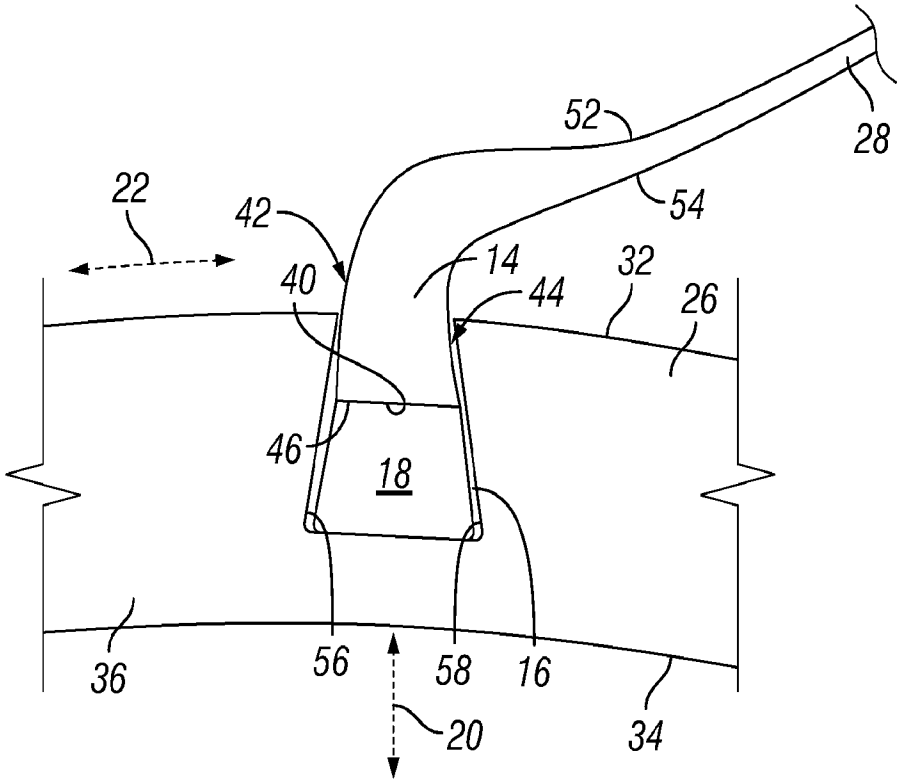

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FIG. 11

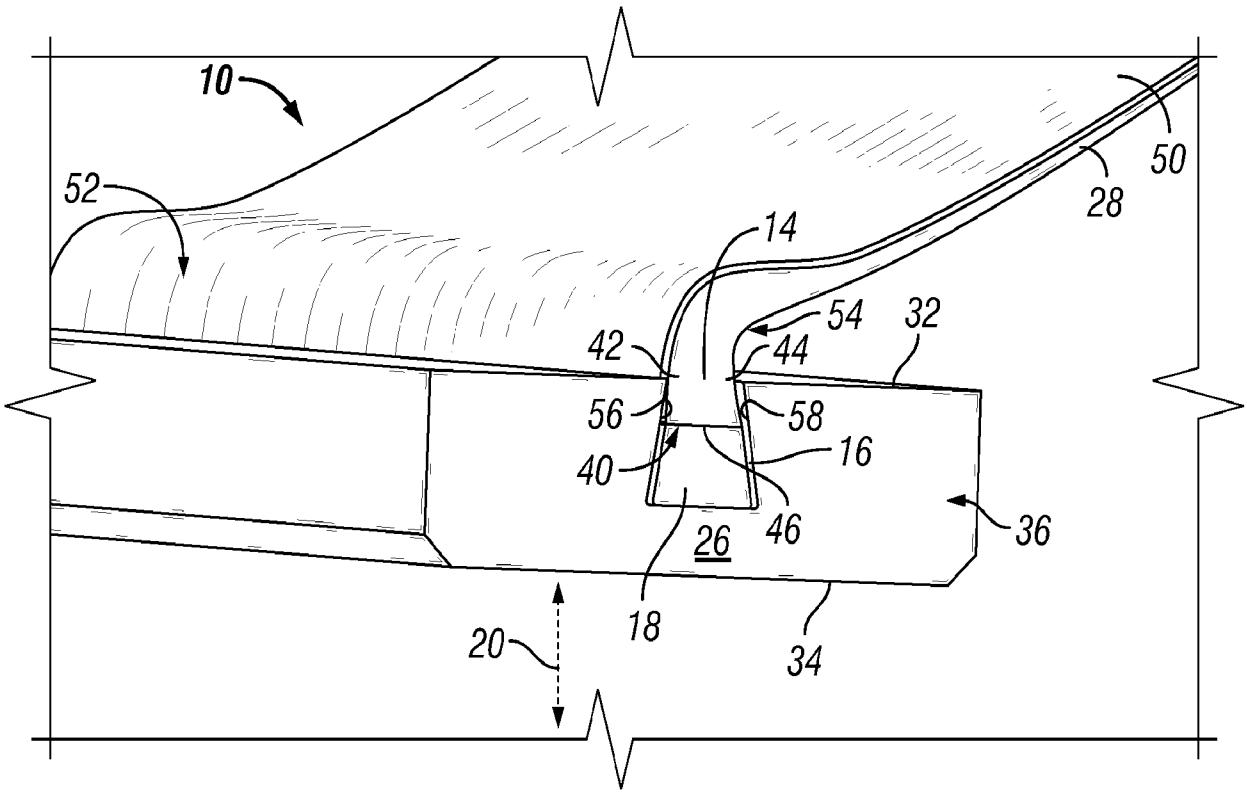


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/069416

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60C7/10 B60B1/04 B60B9/04 B60B9/26 B60C7/14
B60C7/18
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 B60B

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 1 118 487 A (HAYMAN JOHN D [US]) 24 November 1914 (1914-11-24)	1-5, 7-11,13, 14
A	the whole document	6

X	US 995 467 A (KENNEDY HARVEY C [CA]) 20 June 1911 (1911-06-20)	1-5,7,8, 10,11, 13,14
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A	figures 1-4,6	6,9,12, 13

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

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
31 August 2017	14/09/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Jung, Wolfgang

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/069416

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2011/126948 A1 (BOYER GEOFFREY [CA] ET AL) 2 June 2011 (2011-06-02) paragraph [0062] - paragraph [0071]; figures 5-10 paragraph [0085] - paragraph [0094]; figures 21-30 paragraph [0068] - paragraph [0071]	1-5,7-9, 13,14 6,10-12

X A	US 1 059 009 A (STRIETELMEIER JOHN E [US]) 15 April 1913 (1913-04-15) the whole document	1-3,5,8, 10-12,14 4,6,7,9, 13

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A	WO 2011/025491 A1 (MICHELIN RECH TECH [CH]; MICHELIN SOC TECH [FR]; ENDICOTT JIM [US]) 3 March 2011 (2011-03-03) paragraph [0026] - paragraph [0032]; figures 2A-2C paragraph [0035] - paragraph [0038]; figures 4A-4C	1-14

A	WO 2016/109648 A1 (MICHELIN & CIE [FR]; MICHELIN RECH TECH [CH]; CRON STEVEN M [US]; RHYN) 7 July 2016 (2016-07-07) paragraph [0005]	1-14

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International application No
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