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(54) **PNEUMATIC TIRE WITH BUILT IN FASTENER SYSTEM**

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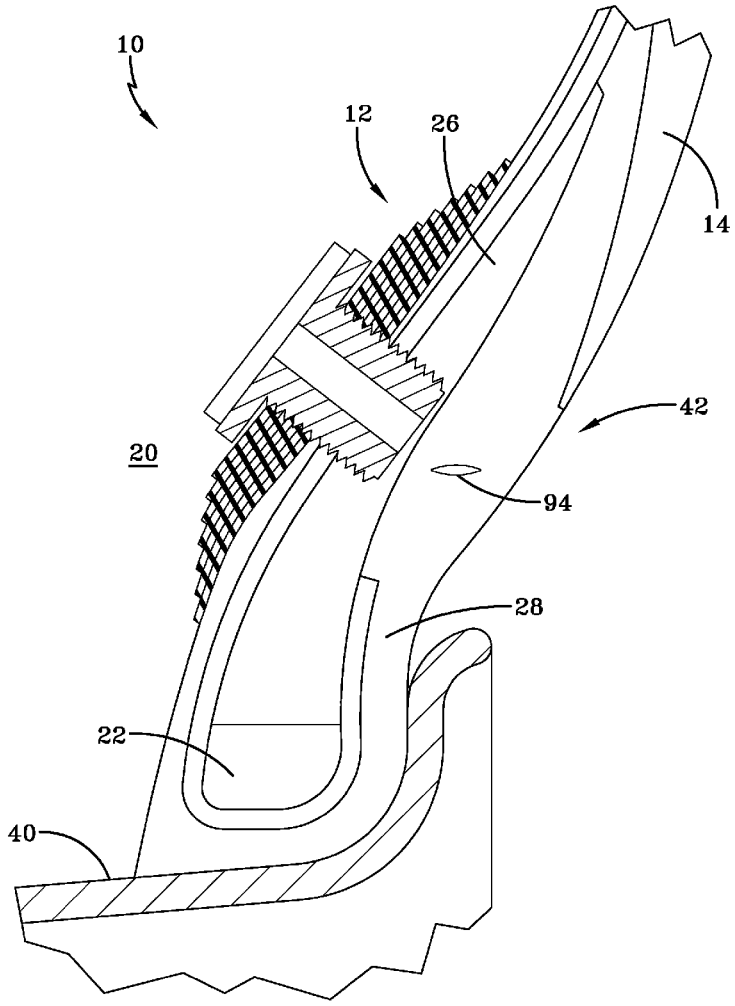
USPC **152/450**; 156/91

(57) **ABSTRACT**

A pneumatic tire assembly includes a pneumatic tire having an inner cavity and an inner surface at least partially defining the inner cavity, a rigid structure for facilitating operation of the tire assembly, and a threaded receptacle for securing the rigid structure to the inner surface of the inner cavity. The threaded receptacle has been integrally bonded to the inner surface during curing of the pneumatic tire.



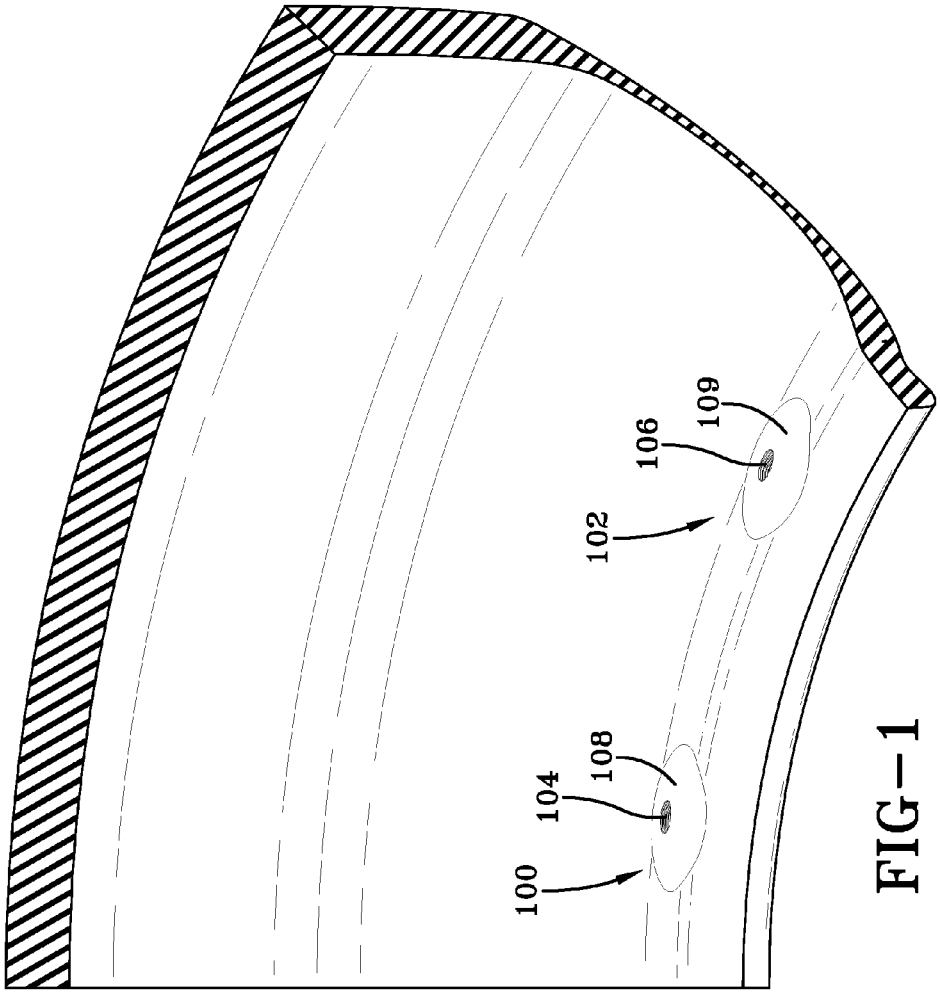


FIG-1

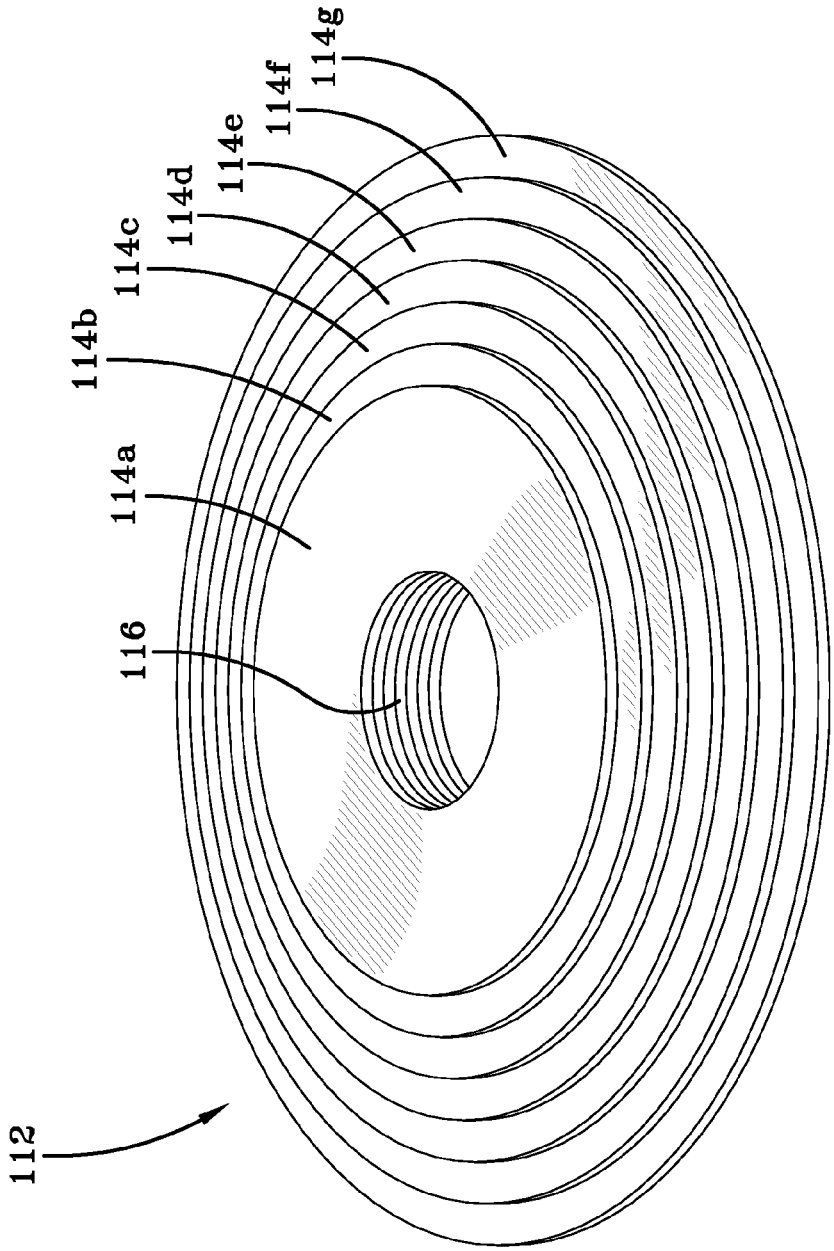
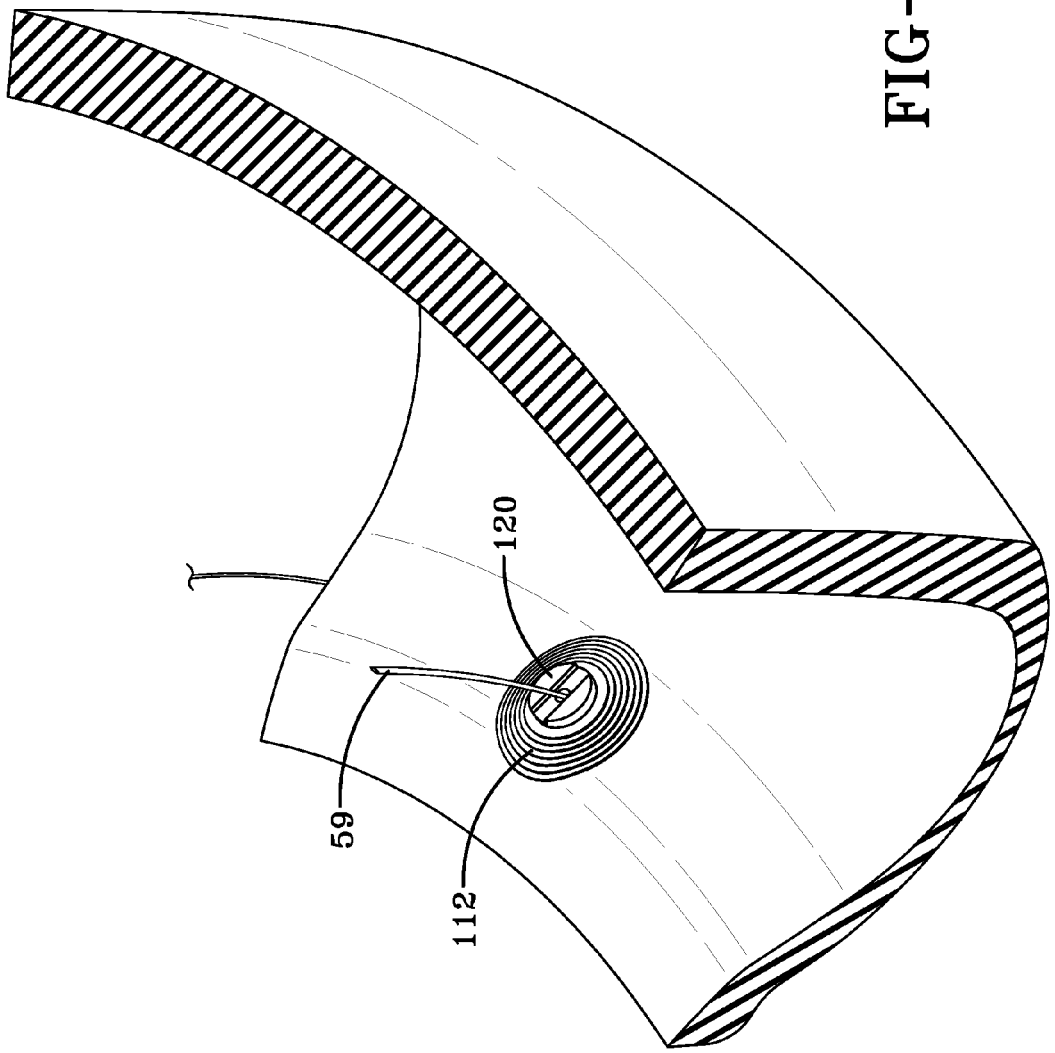


FIG-2



FIG—3

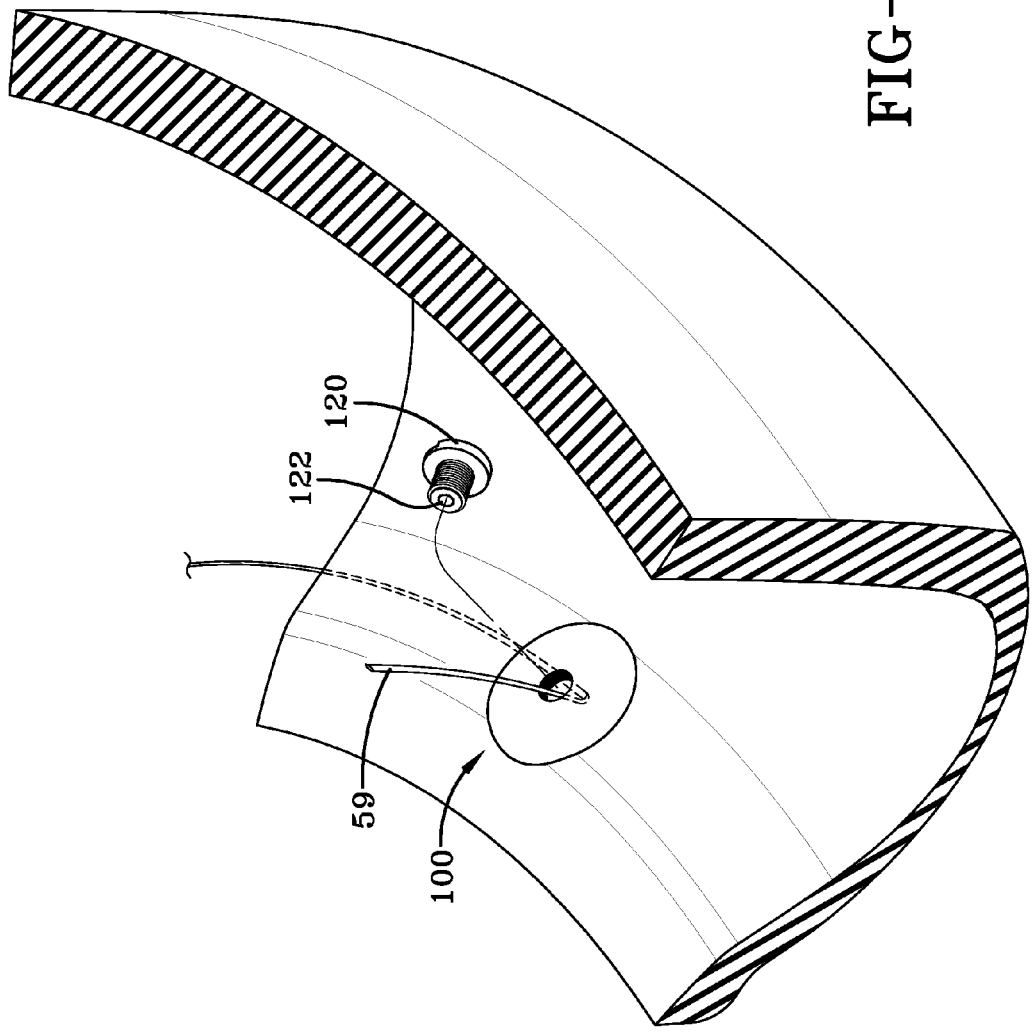


FIG-4

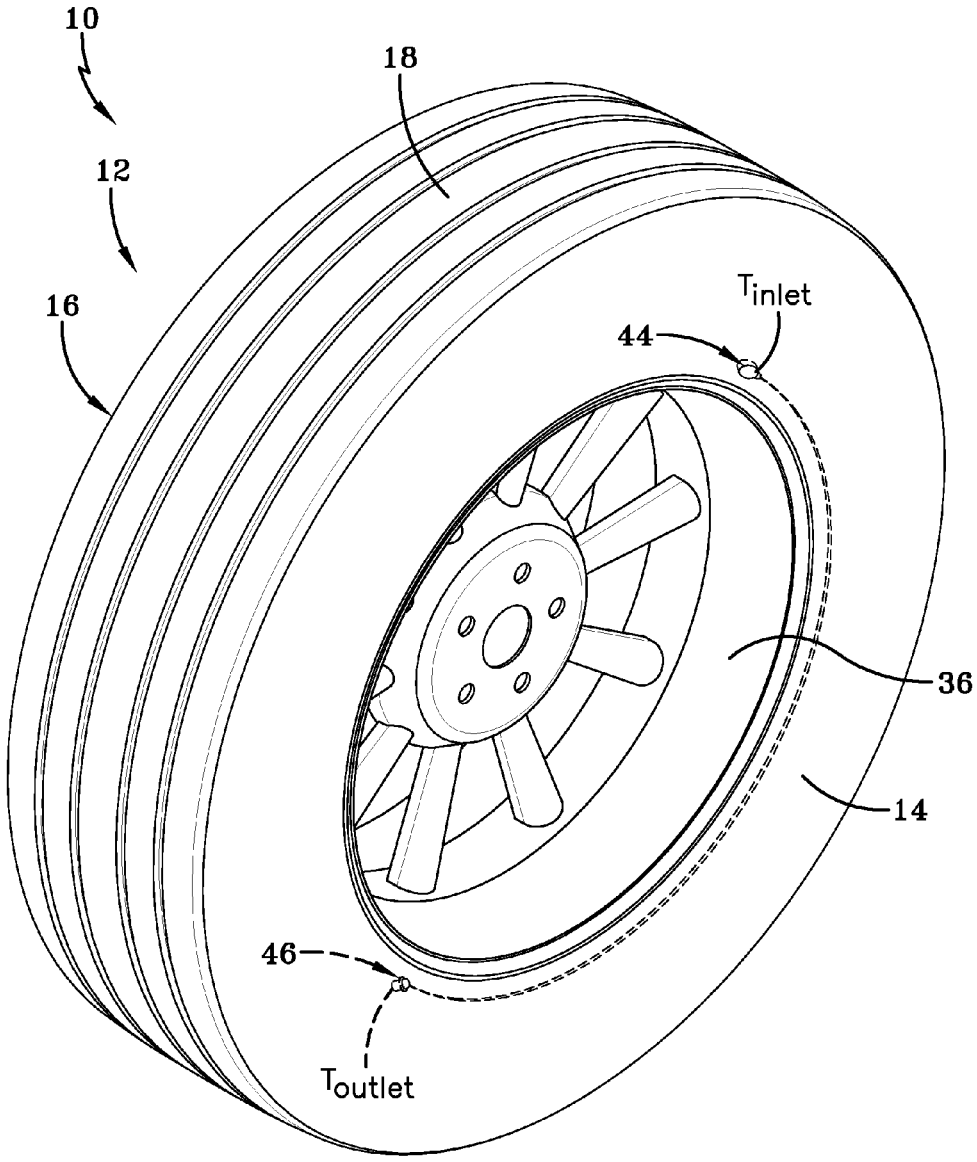


FIG-5

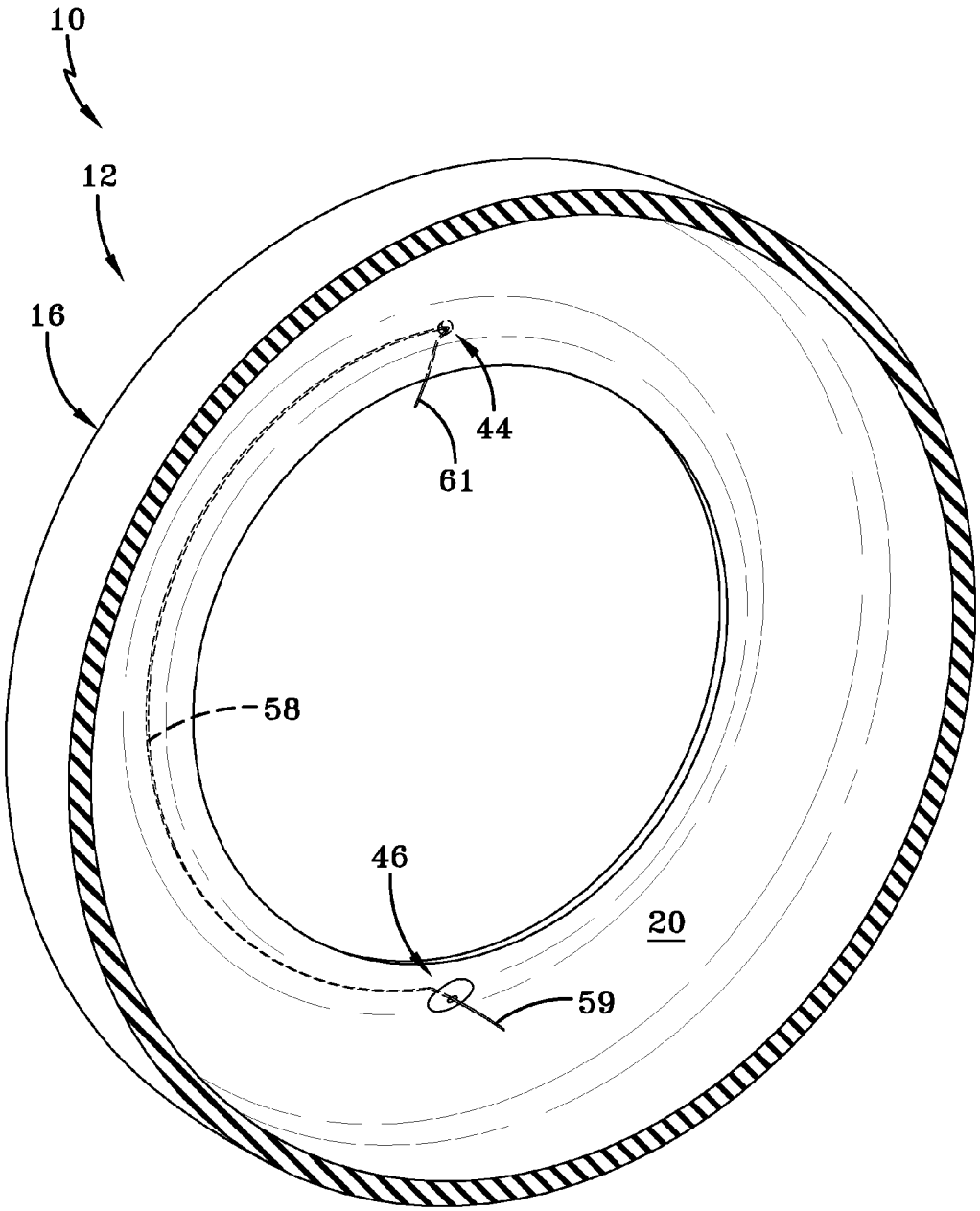


FIG-6

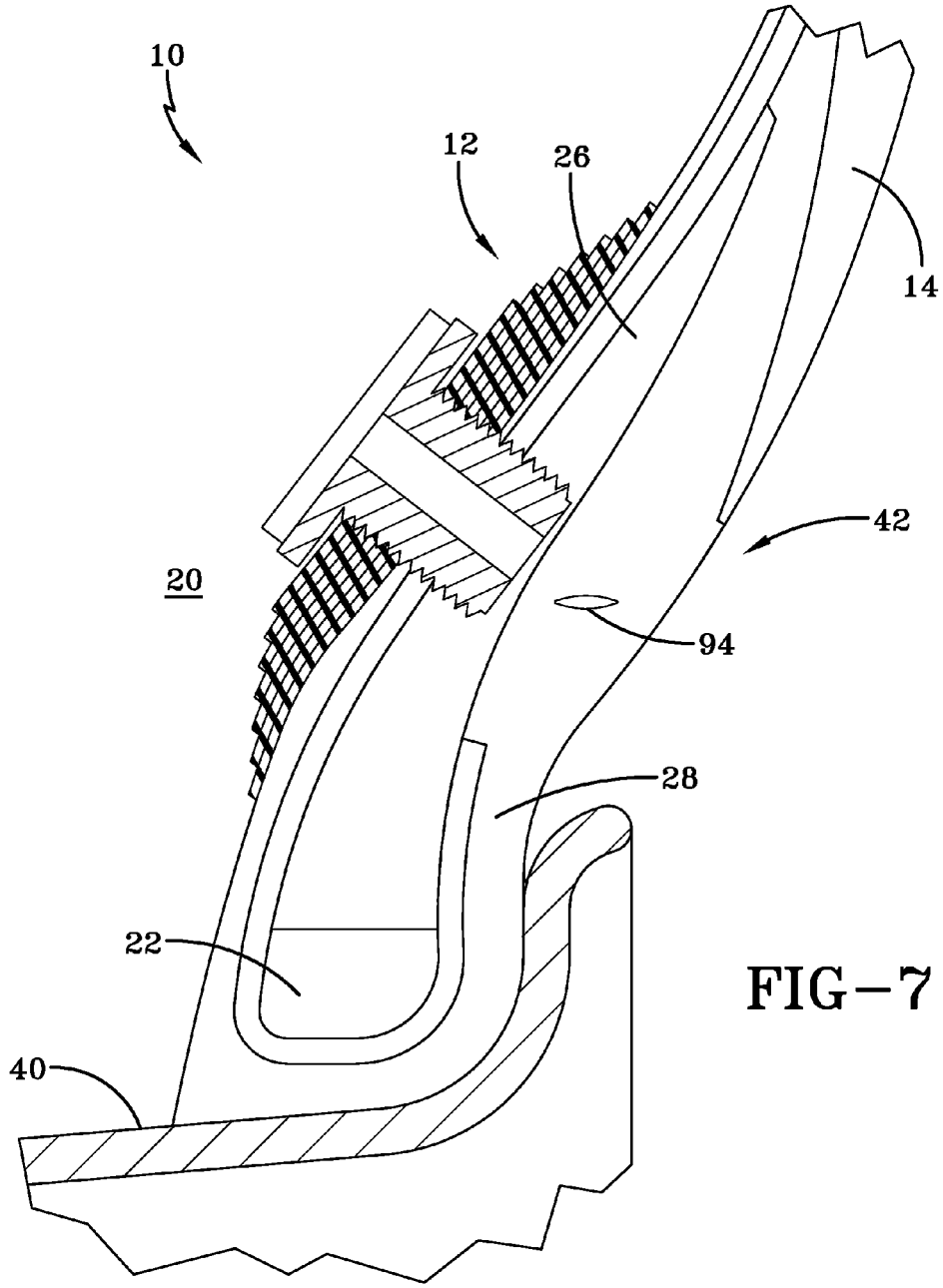


FIG-7

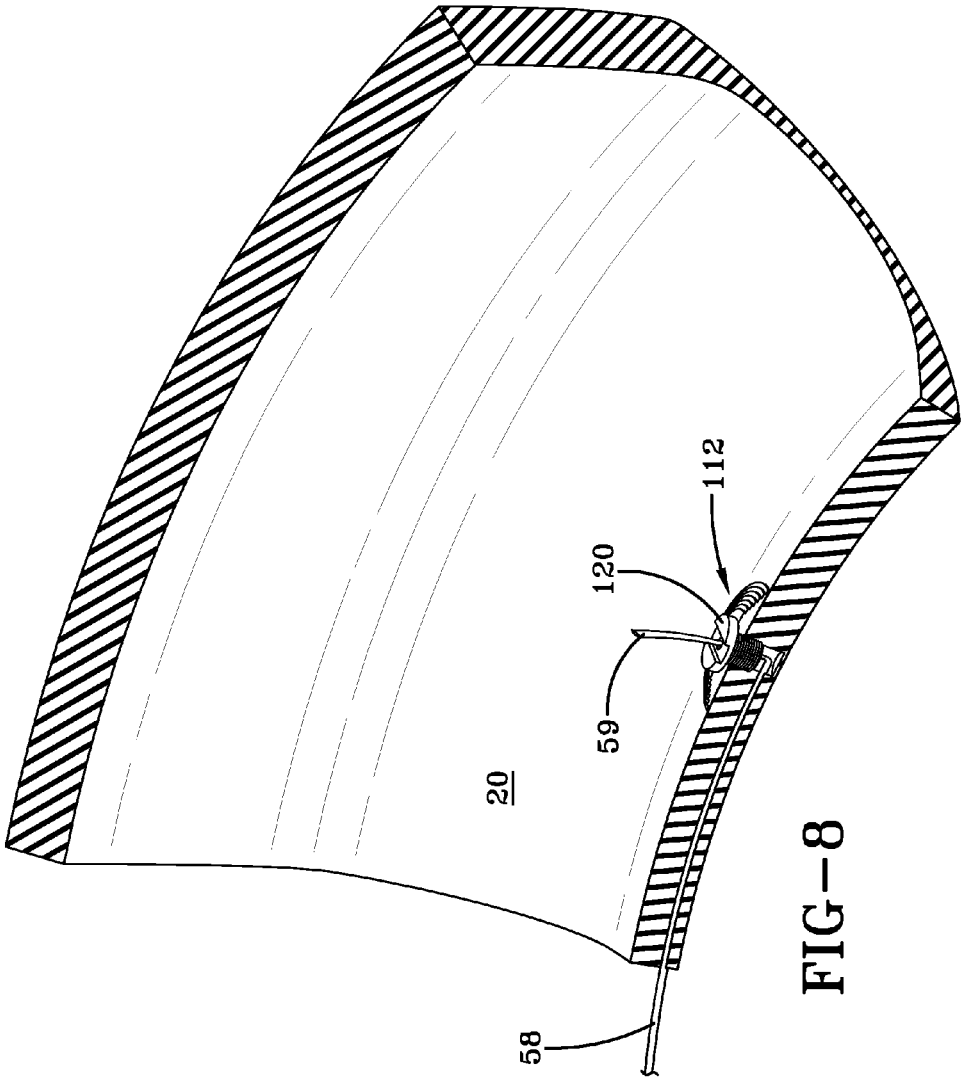
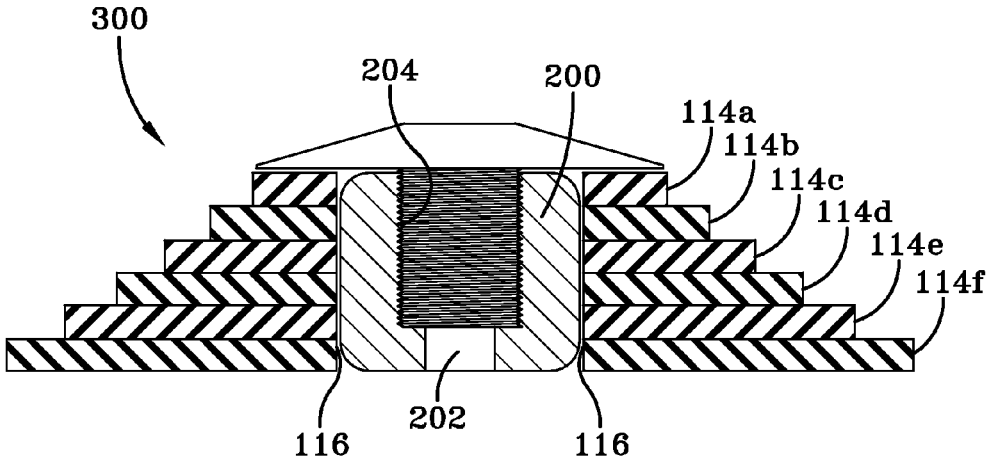
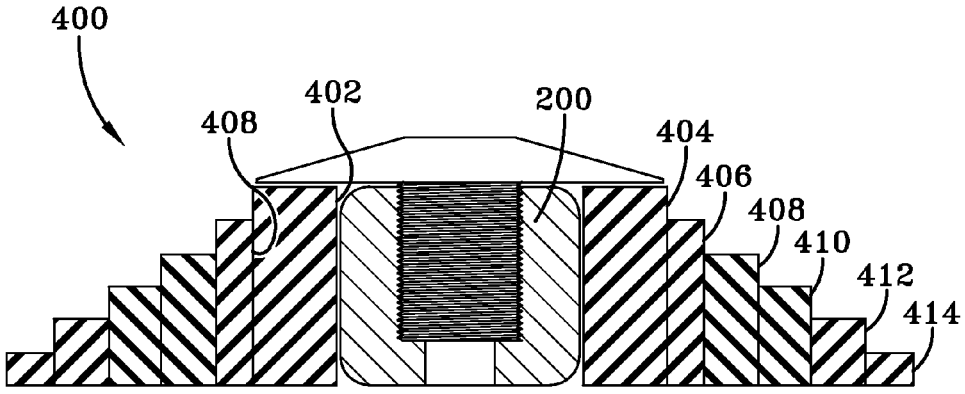


FIG-8


300
204
200
114a
114b
114c
114d
114e
114f
116
202
116

FIG−9


400
408
402
200
404
406
408
410
412
414

FIG−10

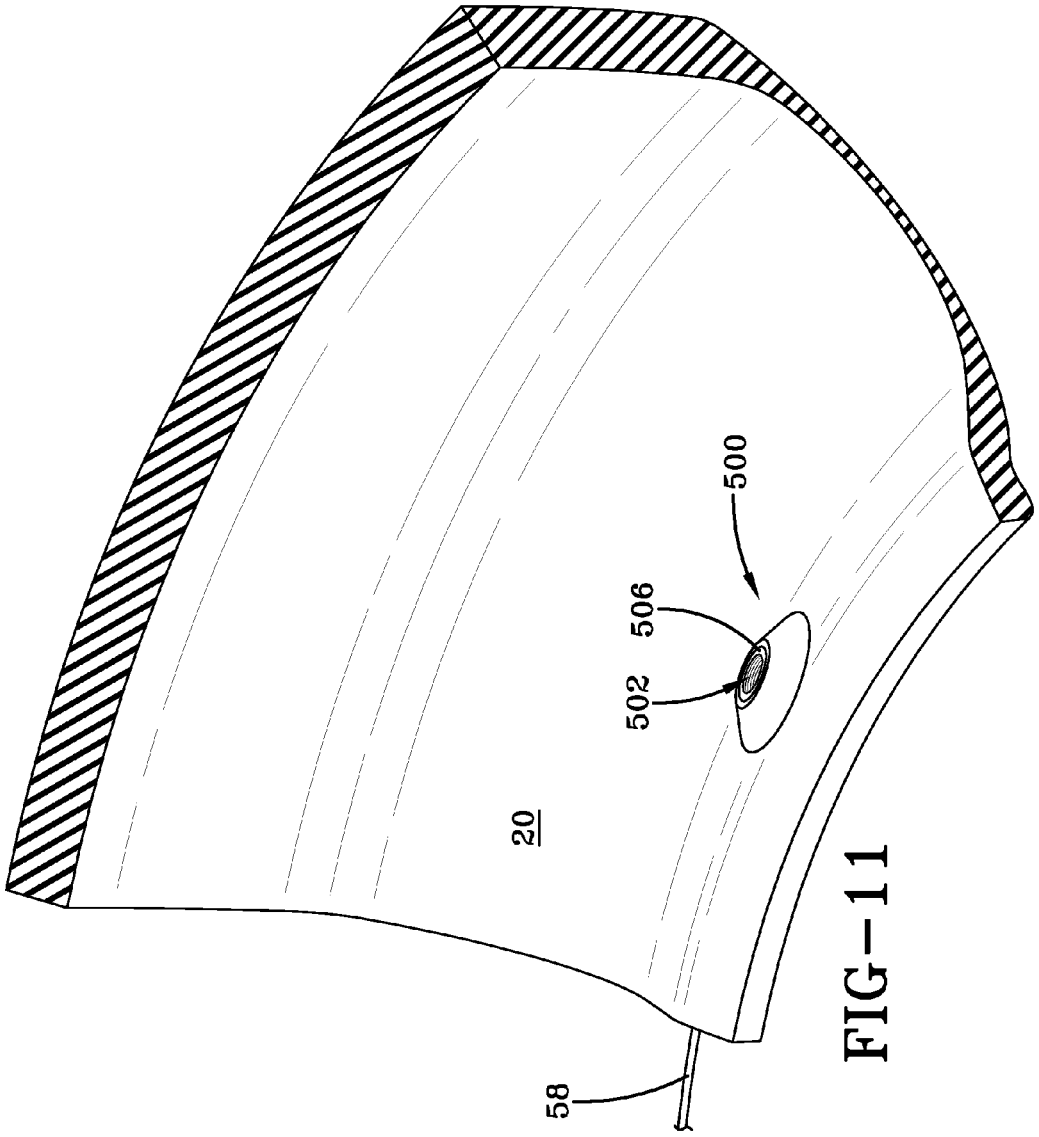


FIG-11

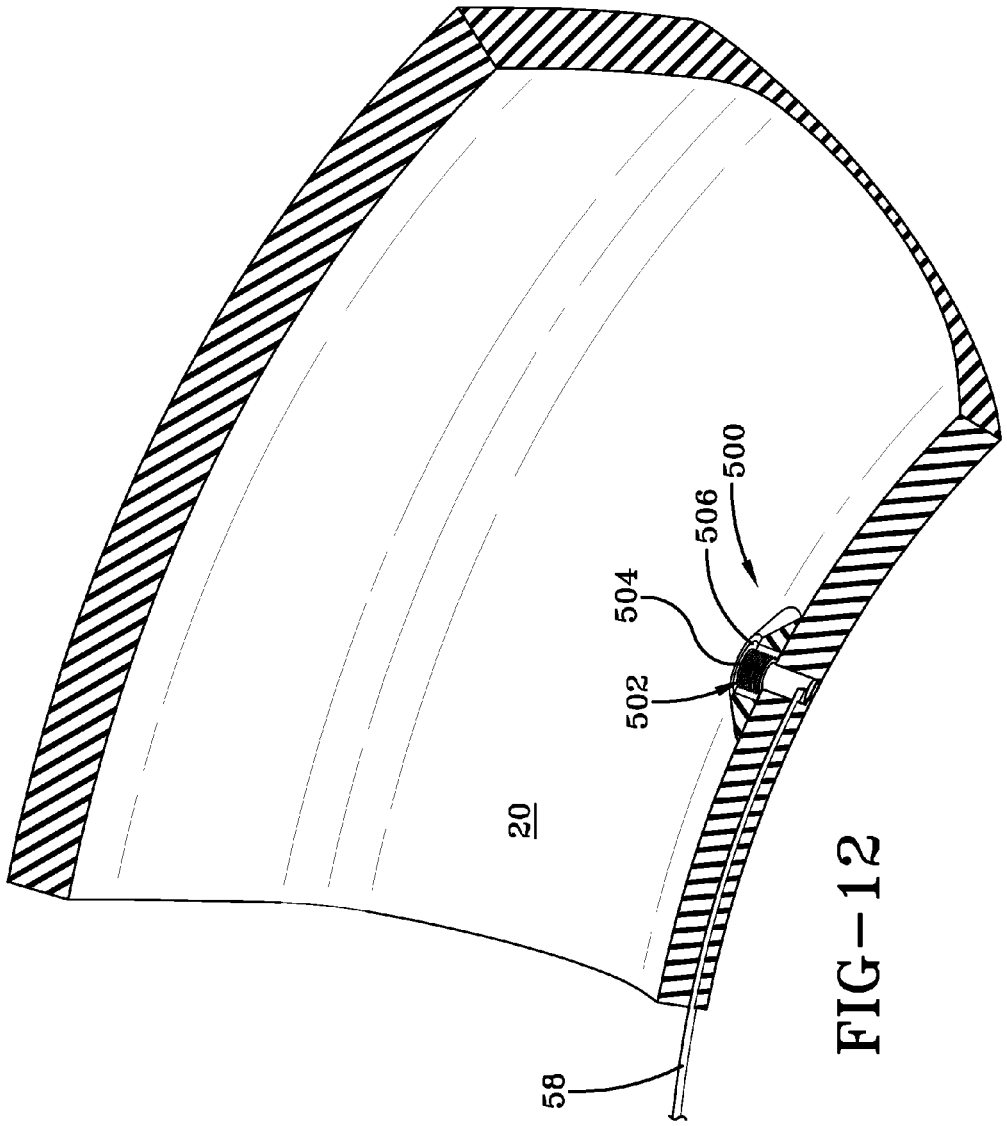


FIG-12

PNEUMATIC TIRE WITH BUILT IN FASTENER SYSTEM

FIELD OF THE INVENTION

[0001] The invention relates generally to tires and securing parts to a pneumatic tire.

BACKGROUND OF THE INVENTION

[0002] Structures in a pneumatic tire may require the attaching or securing of certain parts, functional devices, and connectors to a rubber part of the tire (e.g., the innerliner). In particular, the structures of an air maintenance tire typically include components such as pressure regulating valves, check valves, tubing or bridge connectors and filters to be attached to the tire sidewall within the tire cavity. Such structures typically encounter high stresses during the operating conditions of the tire. Thus, strong attachment of such structures is desired for proper operation of the system as a whole.

SUMMARY OF THE INVENTION

[0003] The invention provides in a first aspect a tire comprising: an interior surface, wherein a receptacle is mounted on the interior surface of the tire, the receptacle having a raised hump formed on the interior surface, and having a mechanical fastener system formed within the raised hump.

[0004] The invention provides in a second aspect a method of securing an object to a tire, including the steps of: attaching two or more concentric layers of elastomeric material to a green tire; inserting a first part of a mechanical fastener system into a hole of the two or more concentric layers; curing the green tire to form a cured tire and to secure the first part of the two piece mechanical fastening system to the cured tire; attaching the object to a second part of the two piece mechanical fastening system; and attaching the first part of the two-piece mechanical fastening system to the second part of the two-piece mechanical fastening system.

[0005] The invention provides in a third aspect a method of securing an object to a tire, including the steps of: attaching two or more concentric layers of elastomeric material to a green tire; molding a first part of a mechanical fastener system into a hole of the two or more concentric layers; curing the green tire to form a cured tire; attaching the object to a second part of the two piece mechanical fastening system; and attaching the first part of the two-piece mechanical fastening system to the molded in second part of the two-piece mechanical fastening system.

[0006] The invention provides in a fourth aspect a tire assembly comprising a tire having a toroidal tire cavity for containing pressurized air; an elongate integral air passageway contained within a flexible tire component, the air passageway extending between an air inlet cavity and an air outlet cavity in the flexible tire component, the air passageway extending for at least a partial circumferential path around the tire; and a receptacle mounted on the interior surface of the tire, the receptacle has a first part of a two part fastener system, wherein the receptacle has a passageway in fluid communication with the air passageway within the flexible tire component.

Definitions

[0007] "Aspect ratio" of the tire means the ratio of its section height (SH) to its section width (SW) multiplied by 100 percent for expression as a percentage.

[0008] "Asymmetric tread" means a tread that has a tread pattern not symmetrical about the center plane or equatorial plane EP of the tire.

[0009] "Axial" and "axially" means lines or directions that are parallel to the axis of rotation of the tire.

[0010] "Chafer" is a narrow strip of material placed around the outside of a tire bead to protect the cord plies from wearing and cutting against the rim and distribute the flexing above the rim.

[0011] "Circumferential" means lines or directions extending along the perimeter of the surface of the annular tread perpendicular to the axial direction.

[0012] "Equatorial Centerplane (CP)" means the plane perpendicular to the tire's axis of rotation and passing through the center of the tread.

[0013] "Footprint" means the contact patch or area of contact of the tire tread with a flat surface at zero speed and under normal load and pressure.

[0014] "Groove" means an elongated void area in a tire dimensioned and configured in section for receipt of an air tube therein.

[0015] "Inboard side" means the side of the tire nearest the vehicle when the tire is mounted on a wheel and the wheel is mounted on the vehicle.

[0016] "Lateral" means an axial direction.

[0017] "Lateral edges" means a line tangent to the axially outermost tread contact patch or footprint as measured under normal load and tire inflation, the lines being parallel to the equatorial centerplane.

[0018] "Net contact area" means the total area of ground contacting tread elements between the lateral edges around the entire circumference of the tread divided by the gross area of the entire tread between the lateral edges.

[0019] "Non-directional tread" means a tread that has no preferred direction of forward travel and is not required to be positioned on a vehicle in a specific wheel position or positions to ensure that the tread pattern is aligned with the preferred direction of travel. Conversely, a directional tread pattern has a preferred direction of travel requiring specific wheel positioning.

[0020] "Outboard side" means the side of the tire farthest away from the vehicle when the tire is mounted on a wheel and the wheel is mounted on the vehicle.

[0021] "Peristaltic" means operating by means of wave-like contractions that propel contained matter, such as air, along tubular pathways.

[0022] "Radial" and "radially" means directions radially toward or away from the axis of rotation of the tire.

[0023] "Rib" means a circumferentially extending strip of rubber on the tread which is defined by at least one circumferential groove and either a second such groove or a lateral edge, the strip being laterally undivided by full-depth grooves.

[0024] "Sipe" means small slots molded into the tread elements of the tire that subdivide the tread surface and improve traction, sipes are generally narrow in width and close in the tires footprint as opposed to grooves that remain open in the tire's footprint.

[0025] "Tread element" or "traction element" means a rib or a block element defined by a shape with adjacent grooves.

[0026] "Tread Arc Width" means the arc length of the tread as measured between the lateral edges of the tread.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The invention will be described by way of example and with reference to the accompanying drawings in which:

[0028] FIG. **1** illustrates a partial inside view of a tire in the sidewall region showing two threaded receptacles of the present invention.

[0029] FIG. **2** illustrates an assembly **112** of concentric rings **114***a-g* used to form the raised humps **108** of the threaded receptacles of FIG. **1**.

[0030] FIG. **3** illustrates the assembly placed in a green tire sidewall area.

[0031] FIG. **4** illustrates a close-up view of the molded threaded passageway formed in the threaded receptacles **108**, **109** post cure.

[0032] FIG. **5** illustrates a tire assembly with air maintenance pump assembly.

[0033] FIG. **6** illustrates a green tire sidewall during the installation of the pump.

[0034] FIG. **7** illustrates a cross-sectional view of a portion of a tire bead area showing the pump tube location.

[0035] FIG. **8** illustrates a schematic of the concentric ring assembly mounted on the tire, prior to cure, shown with a screw inserted therein and a strip extending from the tire sidewall to the hole of the concentric ring assembly.

[0036] FIG. **9** illustrates a front view of alternate embodiment of the invention.

[0037] FIG. **10** illustrates a front view of a second alternate embodiment of the invention.

[0038] FIG. **11** is a perspective view of a third alternate embodiment.

[0039] FIG. **12** is a cross-sectional view of FIG. **11**.

DETAILED DESCRIPTION OF EXAMPLES OF THE PRESENT INVENTION

[0040] FIG. **1** illustrates a partial inside view of a tire in the sidewall region which illustrates a first and second raised receptacle **100**, **102** of the present invention. The raised receptacles **100**, **102** are preferably integrally molded with the green tire during vulcanization, and include a raised surface or hump **108**, **109** formed on the interior surface of the tire. While the receptacles are shown in the tire sidewall area, the receptacles may be located anywhere on the inside or exterior surface of the tire.

[0041] Each raised hump **108**, **109** includes a first part of a fastener mechanism which is preferably centrally located. In this example, the first part of a fastener mechanism is a threaded hole **104**, **106**. Devices such as valves, transducers, filters or other devices have a second part of a fastener system which in this example is a threaded male end, may be secured or screwed into the receptacle as described in more detail, below. The raised receptacle is not limited to a threaded hole, and may include other locking fastener systems known to those skilled in the art. For example, the first part of a fastener mechanism may be a bayonet-style socket that is inserted into the assembly and molded into the tire. The device to be mounted may include the second part of the fastener system which is a bayonet connector for reception into mating engagement with the bayonet socket. Other fastener systems may include snap in fastener, key, spline joint, or retaining ring. Velcro (hook and loop strip) may also be used as the fastener system.

[0042] FIG. **2** illustrates an assembly **112** of concentric stacked layers **114***a-g* used to form the humps **108** of the present invention. While the invention is illustrated as concentric rings, the invention is not limited to the ring shape, as other shapes such as squares, triangles, etc would work for the invention. The assembly **112** is formed of concentric layers of material, wherein the material may be: green rubber or uncured elastomeric or thermoplastic materials or blends thereof. The rubber may be reinforced with short fibers or fabric reinforcements. Preferably, the layers are formed of a green hard rubber compound having a Shore A hardness in the range of about 40 to about 100, and more preferably in the range of about 50 to about 90. Each layer **114***a-g* has an aligned interior hole **116** having the same interior diameter as the other layers **114***a-g*. Starting with the innermost layer **114***g* with the largest outer dimension, the layers **114***a-f* are arranged in a pyramid with layers of decreasing outer dimensions such that the outermost layer **114***a* has the smallest outer diameter.

[0043] The layers forming the assembly **112** are assembled as shown in FIG. **2** and then placed inside a green tire adjacent the innerliner, as shown in FIG. **3**. For an application such as a peristaltic pump assembly, the assembly **112** may be placed in the sidewall area near the chafer. The assembly **112** is temporarily secured to the innerliner using hot gum rubber or rubber adhesive. A screw such as an M5 screw **120** is inserted into hole **116** of the assembly and may be secured using rubber adhesive. The hole diameter **116** is preferably sized so that the hole sidewalls abut the screw surface.

[0044] The green tire is then vulcanized in a tire mold as known to those skilled in the art. After the tire has been vulcanized, the concentric assembly has been vulcanized to form the humps **108**, **109** which are integrally bonded to the tire inner surface. FIG. **4** illustrates that the threads of the screw **120** has formed a threaded passageway molded in the cured tire after removal of screw **120**.

[0045] As shown in FIG. **9**, the concentric layer assembly **112** may be used in conjunction with an insert **200** forming an assembly **300** which is a first part of a fastener system. The insert **200** may be a cylindrically shaped sleeve having an internal hole **202** (or other fastener mechanism (not shown)). Hole **202** extends completely through the insert **200**. The insert **200** is inserted in hole **116** of assembly **112** prior to cure. The insert **200** internal hole **202** preferably is partially threaded **204** to receive a second part of a fastener system such as a threaded end of a valve or other device. The assembly **300** is then affixed to a desired green tire surface such as the internal portion of the sidewall using adhesive. A removable screw is preferably screwed into hole **116** prior to cure. The assembly **300** is permanently molded into the tire with the exception of the removable screw during vulcanization.

[0046] The insert **200** may be made of rubber, preferably green rubber, elastomer, metal, plastic, nylon or ultra high molecular weight polyethylene (UHMWPE) or other known material or combinations thereof. The insert may optionally include threads or protrusions on the exterior surface. The insert may further include a flanged outer end (not shown) in order to secure the insert to the tire. The outer surface of the insert may optionally be roughened and coated with a suitable adhesive such as resorcinol formaldehyde latex (RFL) commonly known as "dip". The outer surface of the insert may further include ridges, flanges, extensions, threads or other mechanical means in addition to the selected RFL to retain it into the rubber of the tire sidewall.

[0047] A third embodiment of an assembly **400** is shown in FIG. **10**. The assembly includes a plurality of annular rings

404 through **414** wherein each ring has an inner hole which encircles another ring. Thus ring **414** encircles the outer surface of ring **412**, and ring **412** has an inner hole which encircles ring **410** and so on. Each ring may have a height H. Preferably the inner most ring **404** is the tallest ring, and the outermost ring is the shortest. The rings are arranged such that the tallest rings are innermost and successively decrease in height towards the outermost ring. The assembly includes an optional insert **200** as described above. The insert is mounted in hole **402** of annular ring **404**. Annular rings **404** and **406** are preferably made of a hard rubber such as known to those skilled in the art to form an apex. Rings **408** and **410** are preferably formed of a hard rubber such as a chafer. Rings **412** and **414** are preferably formed of a rubber used to make ply. Thus the innermost rings **404**, **406** are formed of a green hard rubber compound having a Shore A hardness in the range of about 40 to about 100, and more preferably in the range of about 50 to about 90.

[0048] Alternatively, in place of the concentric layered assembly **112**, a one piece unit **500** having a pyramidal shape as shown in FIG. **11** may be used. The one piece unit may be premolded to a desired shape such as a pyramid. The one piece unit has a center hole **502** which may be threaded **504**. A removable screw may be placed in center hole **502** and used to mold in threads when the assembly **500** is vulcanized in the tire. The one piece unit may optionally include a center sleeve **506** which may be made of a different material than the one piece unit. In place of the screw, a mold to form the shape of the desired fastener may be used, or the fastener device itself may be permanently molded into the tire by insertion prior to cure. The assembly **500** is permanently molded into the tire by affixing to a desired green tire surface such as the internal portion of the sidewall using adhesive. A removable screw is preferably screwed into hole **502** prior to cure. The assembly **500** is permanently molded into the tire with the exception of the removable screw.

[0049] The center sleeve may be made of rubber, preferably green rubber, elastomer, metal, plastic, nylon or ultra high molecular weight polyethylene (UHMWPE) or other known material or combinations thereof. The sleeve may optionally include threads or protrusions on the exterior surface. The sleeve may further include a flanged outer end (not shown) in order to secure the sleeve to the tire. The outer surface of the sleeve may optionally be roughened and coated with the selected RFL. The outer surface of the sleeve may further include ridges, flanges, extensions, threads or other mechanical means in addition to the selected RFL to retain it into the rubber of the tire sidewall.

Embodiment with Peristaltic Pump Assembly

[0050] The following method steps are applicable for the installation of the threaded receptacle **100** to be used in conjunction with the special case of a tire with a peristaltic pump assembly. The receptacles may be used to install pressure regulators, valves, filter and combinations thereof. Thus, the threaded receptacles must be installed in such a manner so that the devices installed in the receptacles are in fluid communication with the pump fluid passageway in the tire.

[0051] Referring initially to FIG. **5**, a tire having an air maintenance assembly system **10** is shown provided within one (FIG. **7**) or both (not shown) sidewalls **14**, **16** of the tire **12**. The air maintenance assembly **42** may be configured to extend between an air entry or inlet cavity **44** and an air exit or outlet cavity **46** within the sidewall **14**, **16**. The air maintenance assembly **42** may incorporate a thin hollow tube **94** within a flexible tire component, such as the chafer **28**, wherein the tube is formed during tire construction with a strip, which is them removed post cure to form the tube **94**. The location selected for the hollow tube within the tire **12** may be within a tire component residing within a high flex region of the tire, sufficient to progressively collapse the peristaltic internal hollow tube as the tire rotates under load thereby conveying air along the hollow tube from the inlet cavity **44** to the outlet cavity **46** and the tire cavity **20**. This AMT (Air Maintenance Tire) assembly **42** may thus function as an internal peristaltic air pump for the tire **12**. The pump is shown as a 180 degree configuration, but could be any desired configuration such as 90 degrees, **270**, **360**.

[0052] A flexible green (uncured) tire component such as a chafer **28**, may have a groove formed therein wherein the groove has opposed groove walls. A silicone strip, cable, or wire (hereinafter strip) **58** is placed in the groove between the groove walls, and then the walls stitched closed. The strip may optionally be encased in green rubber prior to placement within the tire component groove. The chafer or tire component with the strip is installed in the tire during the tire building process. Holes are punched in the green tire at the location of the inlet **44** and outlet **46**. The strip **58** is preferably dimensioned such that the ends **59**, **61** extend a distance beyond the inlet/outlet holes **44**, **46** at opposite ends of the chafer strip.

[0053] A concentric assembly **112** is positioned at the location of the punched holes **44**, **46** on the inside surface of the tire. A first end **59** of the strip is positioned so that it extends through inlet punched hole **46** on the interior surface of the tire, and through hole **116** of concentric ring assembly **112**. The threaded end of a screw or other fastener system is positioned in hole **116**, wherein the strip end **59** is inserted through a central hole of the screw or fastener system. FIG. **3** illustrates the assembled configuration pre-cure. The procedure is repeated for outlet punched hole **44**. It is important that the strip be threaded through each hole **44**, **46** and through the central hole **122** of screw **120** in order to form a continuous molded in passageway from each of the threaded receptacles to the pump tube **94**. After the tire is cured, the strip is removed forming a continuous air passageway **94** from the threaded receptacle at the inlet end **46**, through the interior of the tire sidewall, and to the threaded receptacle at the outlet **48**. Preferably, an inlet control or pressure regulator valve (not shown) having a male threaded end is threadably received in the inlet end receptacle. The inlet control valve controls the air flow into the pump. It is also preferred that a check valve having a male threaded end (not shown) is screwed into the receptacle located at the pump outlet end. The check valve is in fluid communication with the tire cavity so that fluid may flow into the tire cavity to maintain the tire pressure at a desired pressure, while preventing cavity air from back flowing into the pump. This continuous air passageway ensures that upon installation of a valve or filter into the threaded receptacle, that the valve, filter or other component is in fluid communication with the pump passageway.

[0054] As described above, the air maintenance assembly **42** may represent a peristaltic air pump system in which the compressible air passageway progressively pumps air along the passageway from the inlet to the outlet and the tire cavity **20** for maintaining internal tire cavity pressure at a required level. The inlet and the outlet may be positioned in the range of about 90 to 360 degrees apart, separated by the internal air passageway. The tire **12** may rotate in a direction of rotation and cause a footprint to be formed against the contact/ground

surface. A compressive force may be directed into the tire **12** from the footprint and may act to flatten a segment of the air passageway adjacent the footprint. Flattening of the segment of the passageway may force air from the segment along the internal passageway in a direction toward the pump outlet.

[0055] The sequential flattening of the air passageway segment by segment may thus cause evacuated air from the flattened segments to be pumped to the pump outlet. When the air flow pressure is sufficient against the permanent outlet assembly, the outlet assembly may open to allow air to flow through the outlet assembly into the tire cavity **20**. This air may thereby serve to re-inflate the tire **12** to a desired pressure level as needed.

[0056] With the tire **12** continuing to rotate, flattened tube segments may be sequentially refilled by air flowing into the inlet assembly along the passageway. The inflow of air from the inlet may continue until the outlet becomes adjacent the tire footprint. When the tire **12** rotates further, the inlet will eventually pass the tire footprint against ground surface, and airflow may resume to the outlet along the passageway.

[0057] The above-described cycle may then be repeated for each tire revolution, "half" depending on the pump length of each rotation resulting in pumped air going to the tire cavity **20** and "half" depending on the pump length of the rotation resulting in pumped air being directed back out the inlet. It will be appreciated that the subject tire assembly and its peristaltic pump assembly **42** may function in like manner in either direction of rotation. The peristaltic pump assembly **42** is accordingly bi-directional and equally functional with the assembly moving in a forward or an opposite, reverse direction of rotation.

[0058] Variations in the present invention are possible in light of the description of it provided herein. While certain representative embodiments and details have been shown for the purpose of illustrating the subject invention, it will be apparent to those skilled in this art that various changes and modifications can be made therein without departing from the scope of the subject invention. It is, therefore, to be understood that changes can be made in the particular embodiments described which will be within the full intended scope of the invention as defined by the following appended claims.

What is claimed:

1. A tire comprising: an interior surface, wherein a receptacle is mounted on the interior surface of the tire, the receptacle having a raised hump formed on the interior surface, and having a first part of a mechanical fastener system formed within the raised hump.

2. The tire of claim **1** wherein the first part of the mechanical fastener system is a threaded passageway.

3. The tire of claim **1** wherein the first part of the mechanical fastener system is a bayonet socket, a snap in fastener, a key, a spline joint or a retaining ring.

4. The tire of claim **1** wherein the first part of the mechanical fastener system is a hook and loop strip.

5. The tire of claim **1** wherein the first part of the mechanical fastener system is an insert.

6. The Tire of claim **1** wherein the insert is made of nylon, brass, metal, plastic or ultra high molecular weight polyethylene.

7. A method of securing an object to a tire, including the steps of: attaching two or more concentric layers of elastomeric material to a green tire; inserting a first part of a mechanical fastener system into a hole of the two or more concentric layers; curing the green tire to form a cured tire and to secure the first part of the two piece mechanical fastening system to the cured tire; attaching the object to a second part of the two piece mechanical fastening system; and attaching the first part of the two-piece mechanical fastening system to the second part of the two-piece mechanical fastening system.

8. A method of securing an object to a tire, including the steps of: attaching two or more concentric layers of elastomeric material to a green tire; molding a first part of a mechanical fastener system into a hole of the two or more concentric layers; curing the green tire to form a cured tire; attaching the object to a second part of the two piece mechanical fastening system; and attaching the first part of the two-piece mechanical fastening system to the molded in second part of the two-piece mechanical fastening system.

9. The tire of claim **8** wherein the first part of the mechanical fastener system is an internal threaded passageway, a bayonet socket, a snap in fastener, a key, a spline joint or a retaining ring.

10. A tire assembly comprising:

a tire having a toroidal tire cavity for containing pressurized air;

an elongate integral air passageway contained within a flexible tire component, the air passageway extending between an air inlet cavity and an air outlet cavity in the flexible tire component, the air passageway extending for at least a partial circumferential path around the tire; and

a receptacle mounted on the interior surface of the tire, the receptacle has a first part of a two part fastener system, wherein the receptacle has a passageway in fluid communication with the air passageway within the flexible tire component.

11. The tire assembly of claim **10** wherein the receptacle is in fluid communication within the tire cavity.

12. The tire assembly of claim **10** wherein a device having a second part of a two part fastener system is secured within the receptacle.

13. The tire assembly of claim **12** wherein the device is a filter having a threaded end that is screwed into the receptacle.

14. The tire assembly of claim **10** wherein the receptacle is raised from the surface of the tire forming a hump.

15. The tire assembly of claim **10** wherein the receptacle further comprises a metal sleeve having a threaded internal passageway.

16. The tire assembly of claim **10** wherein the first part of the mechanical system is a bayonet socket, and the second part is a bayonet.

17. The tire assembly of claim **10** wherein the first part of fastener system is molded into tire.

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