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Marie Hinue et al.

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(54) **CONNECTOR SYSTEM AND AIR MAINTENANCE TIRE ASSEMBLY**

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(71) Applicant: **The Goodyear Tire & Rubber Company, Akron, OH (US)**

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(72) Inventors: **Daniel Paul Luc Marie Hinue, Habay-la-Neuve (BE); Gilles Bonnet, Niederfeulen (FR); Olivier Di Prizio, Hettange-Grande (FR); André Cuny, Habay-la-Neuve (BE); Sebastien Lembert, Villers Le Rond (FR); Andreas Frantzen, Trier (DE)**

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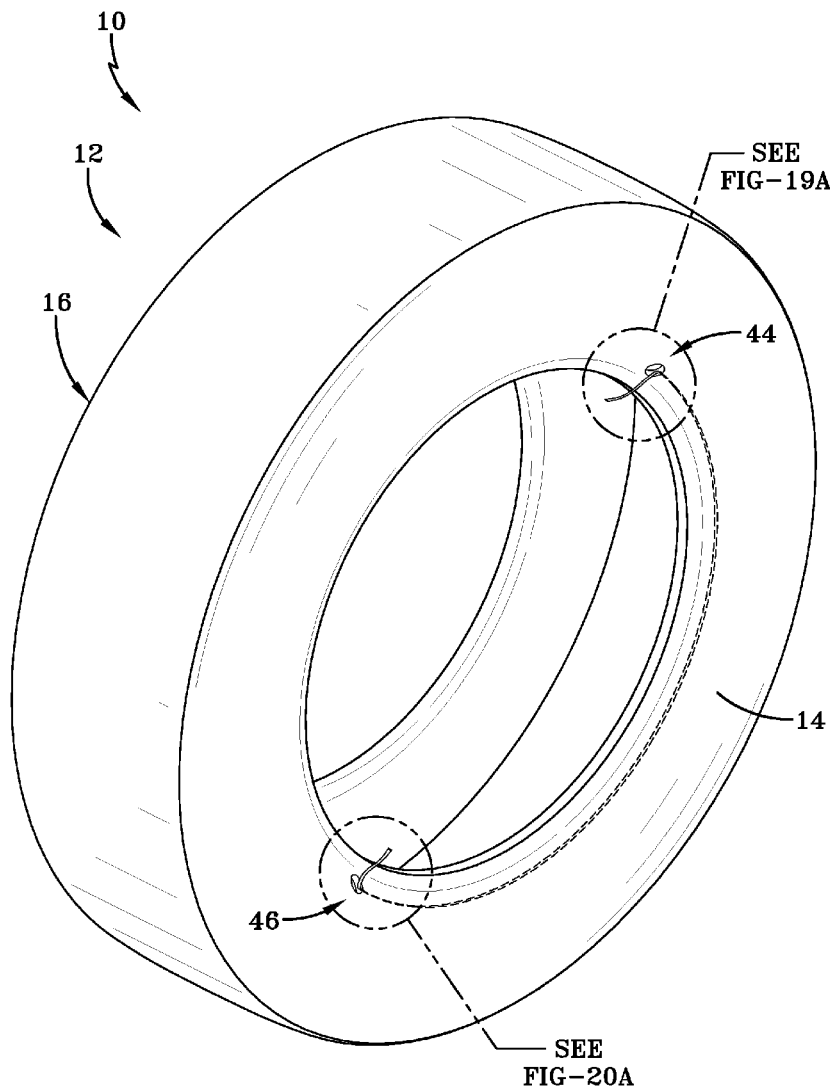
(73) Assignee: **The Goodyear Tire & Rubber Company, Akron, OH (US)**

(57) **ABSTRACT**

(21) Appl. No.: **13/677,411**

A connector system and tire assembly includes 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 metallic connector assembly within the outlet cavity, the connector assembly including a through-channel for conducting air flow communication between the air passageway within the flexible tire component and a chamber of the connector assembly.

(22) Filed: **Nov. 15, 2012**



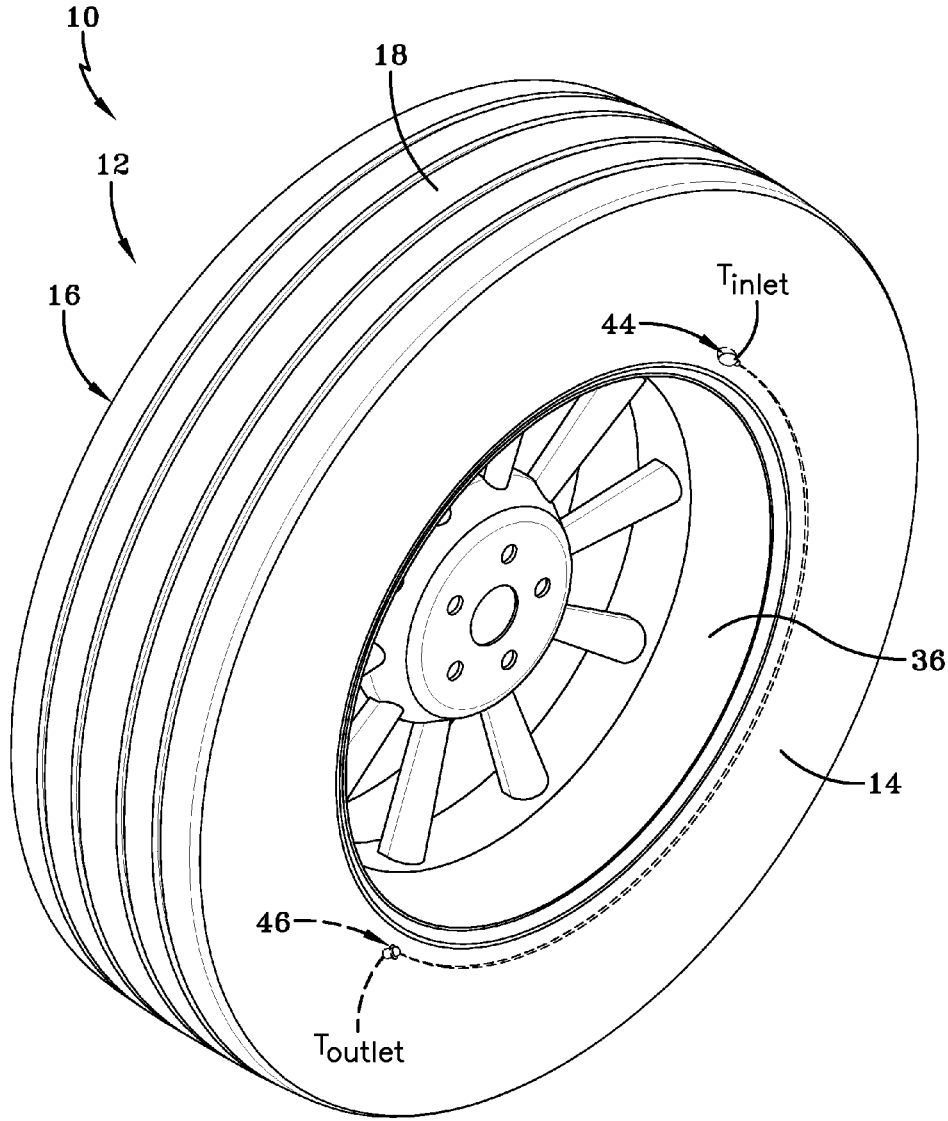


FIG-1

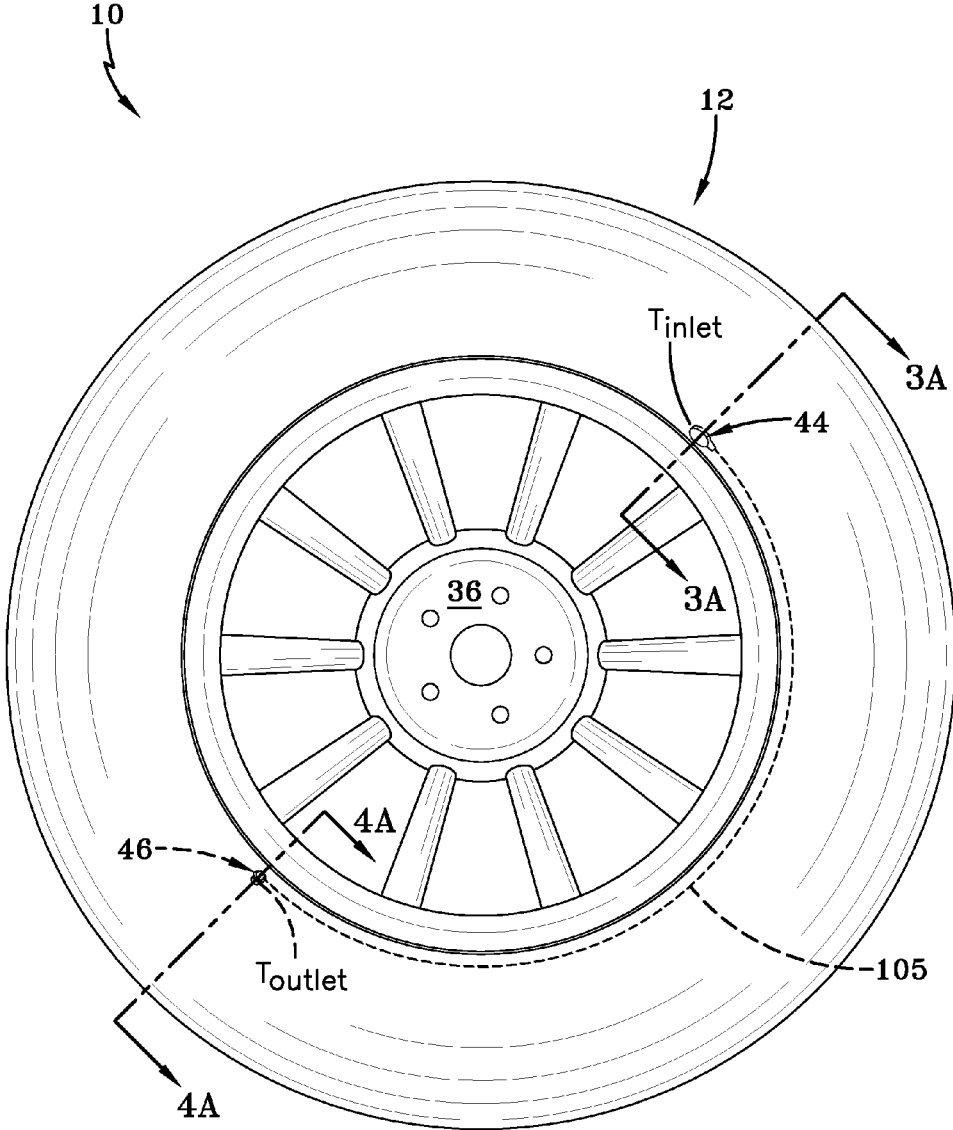


FIG-2

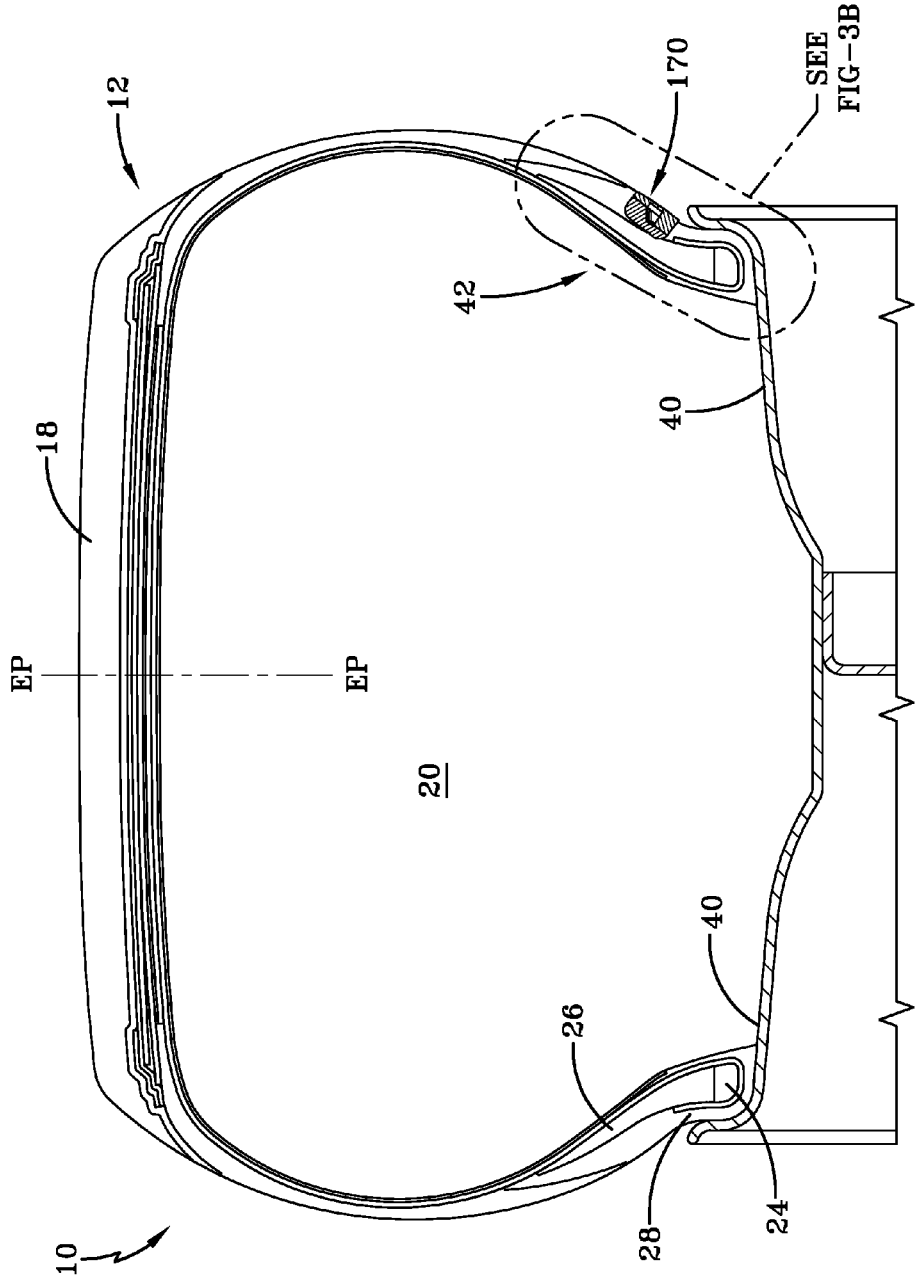


FIG-3A

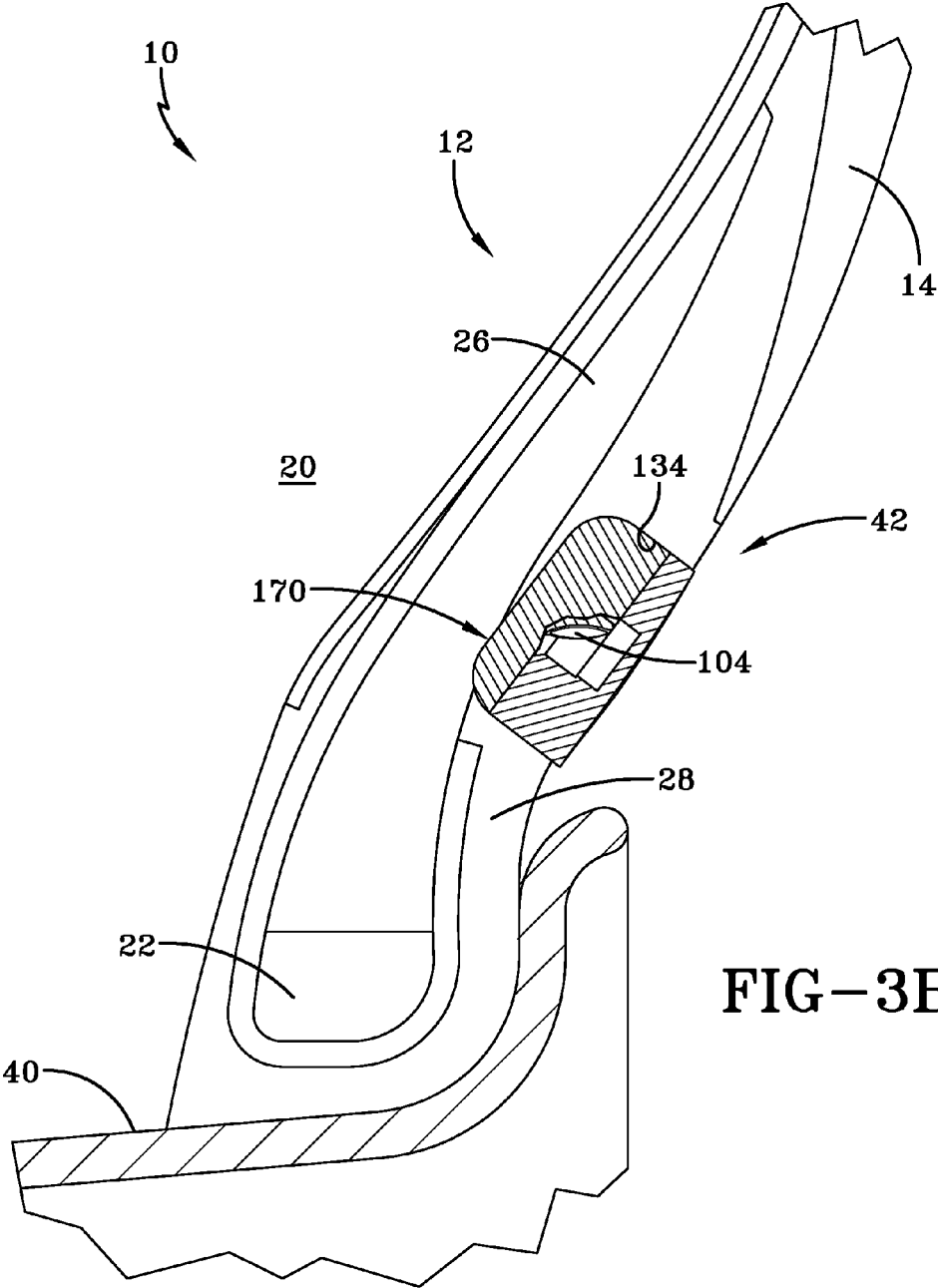


FIG-3B

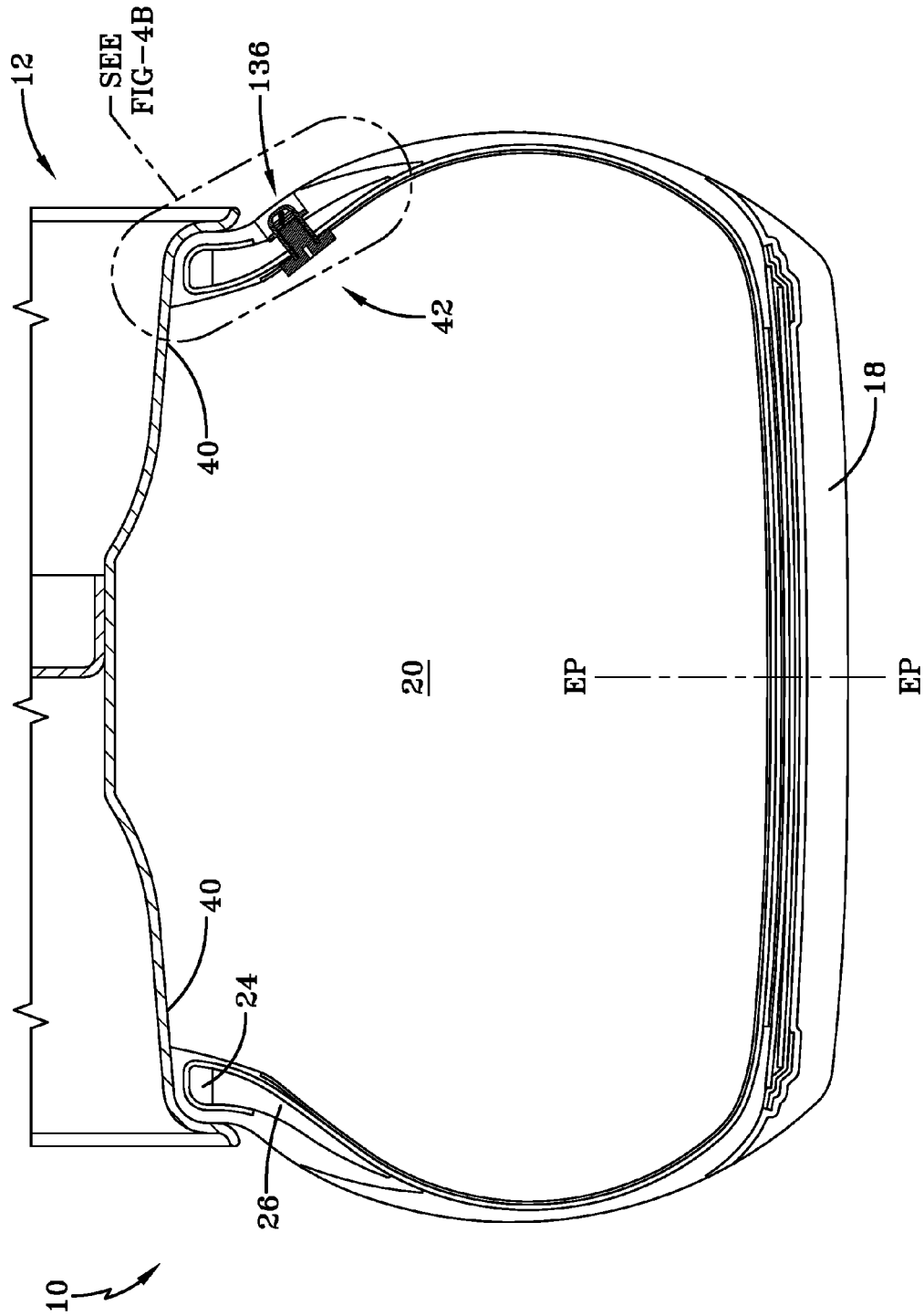


FIG-4A

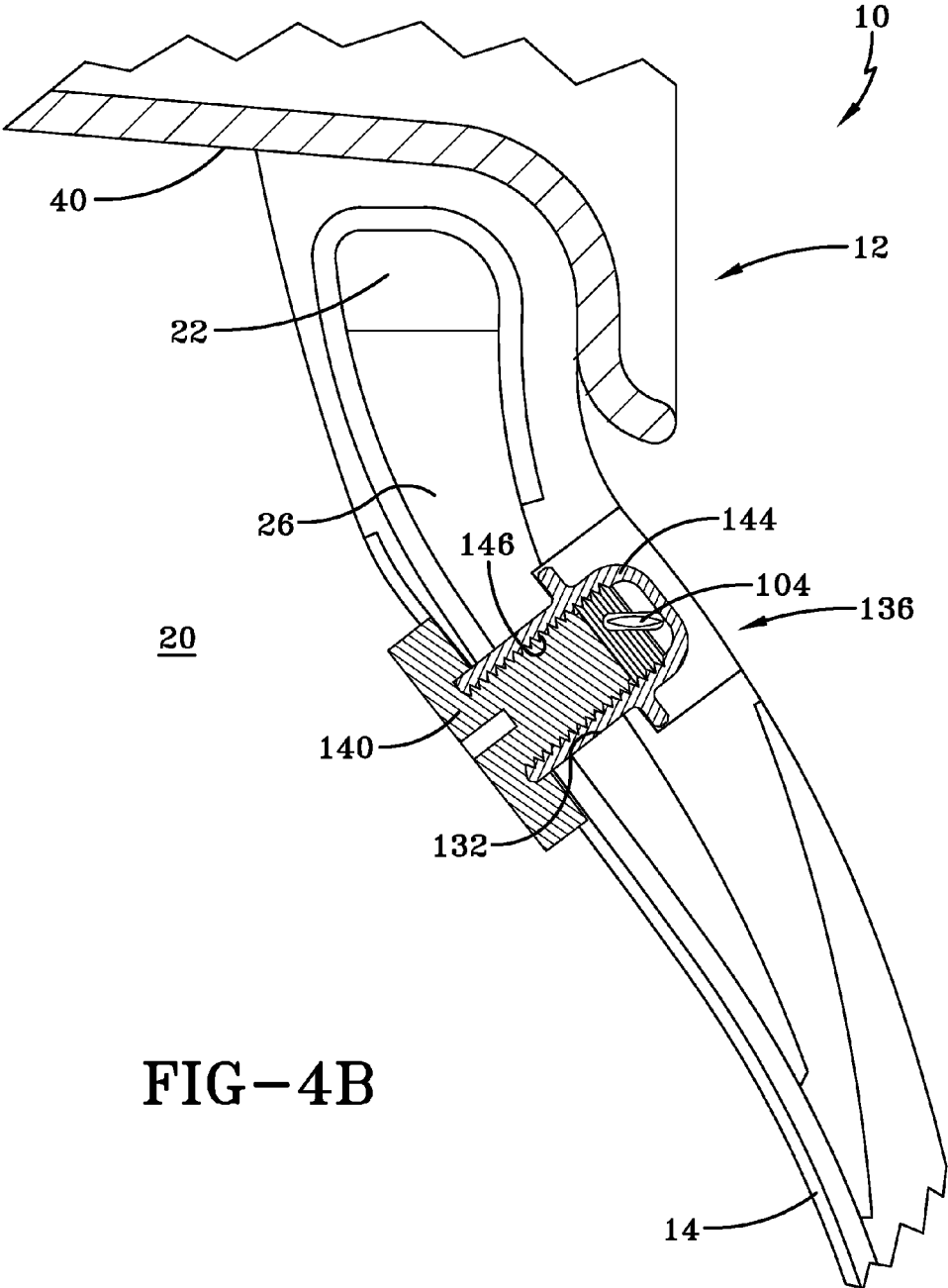


FIG-4B

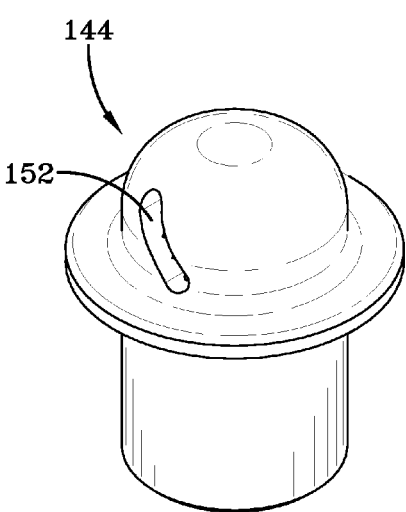


FIG-5A

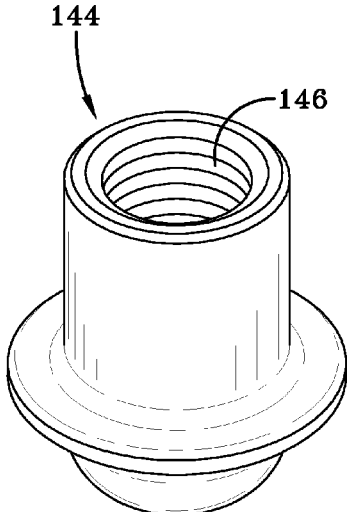


FIG-5B

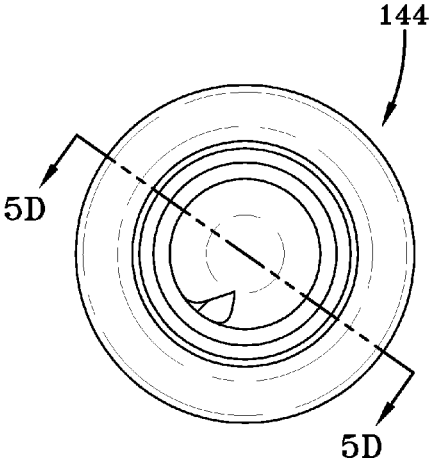


FIG-5C

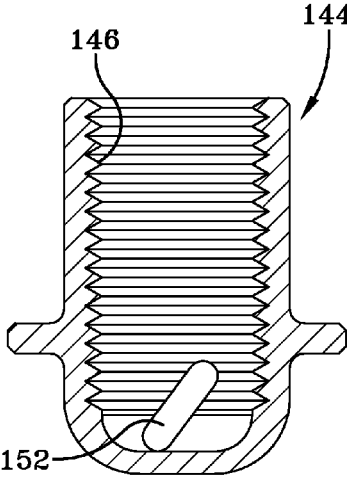
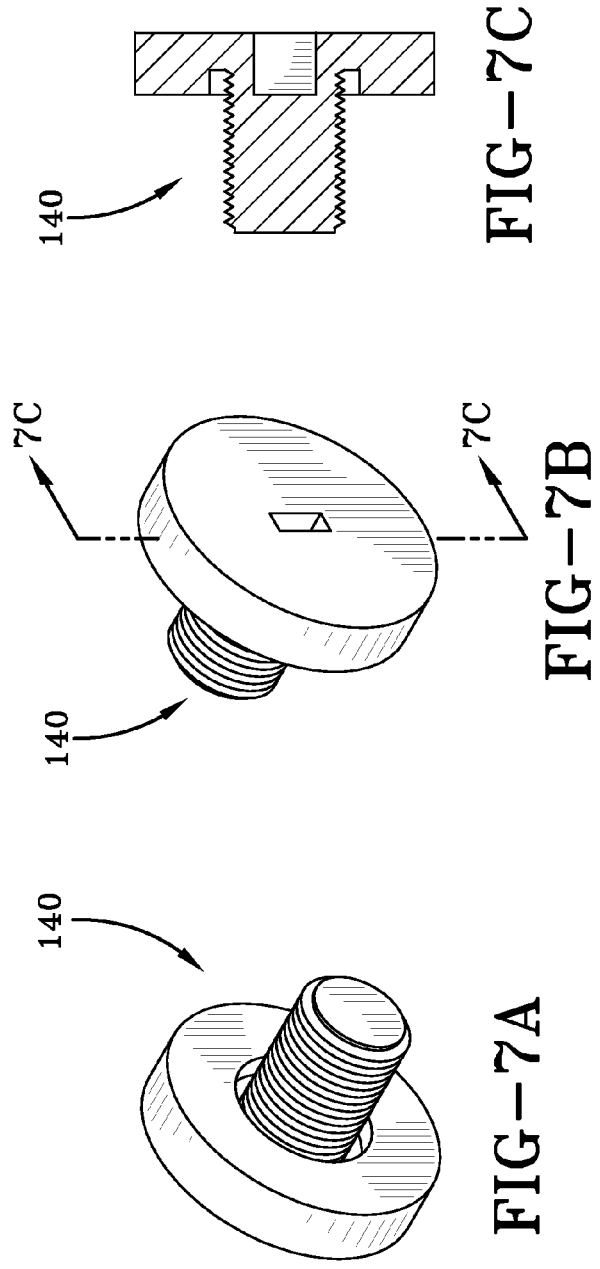
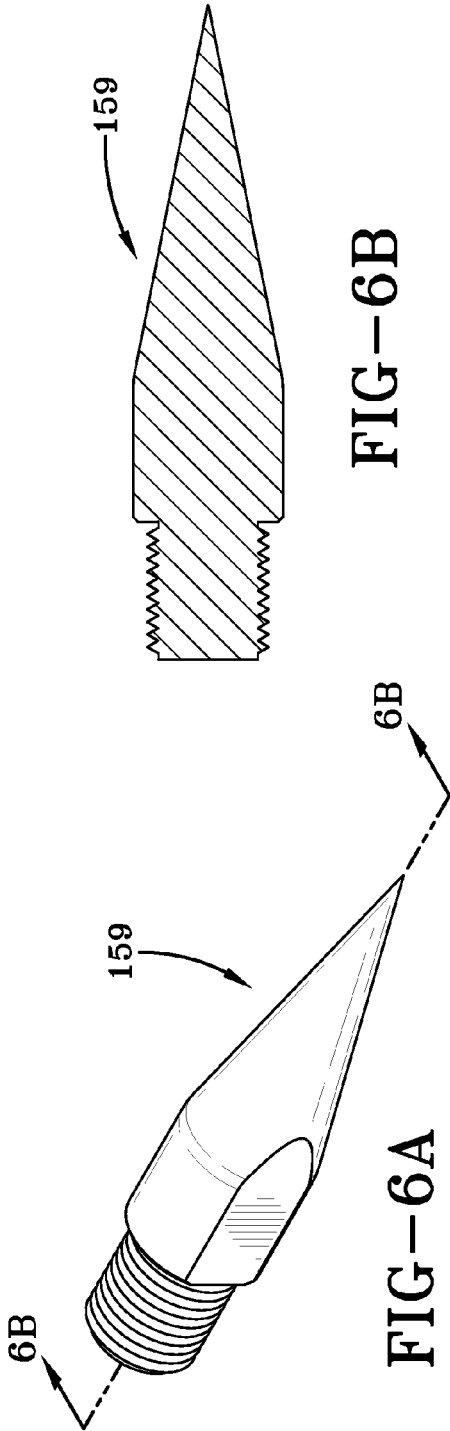


FIG-5D



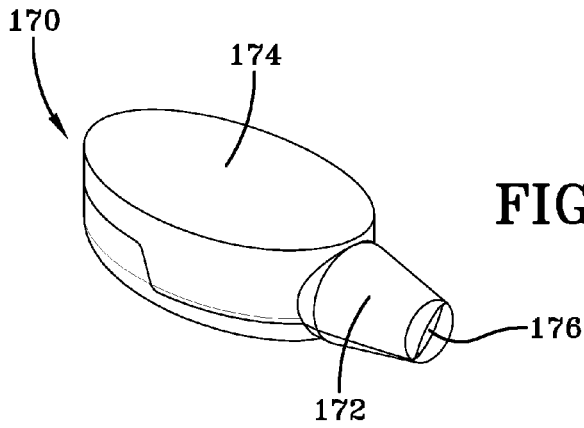


FIG-8A

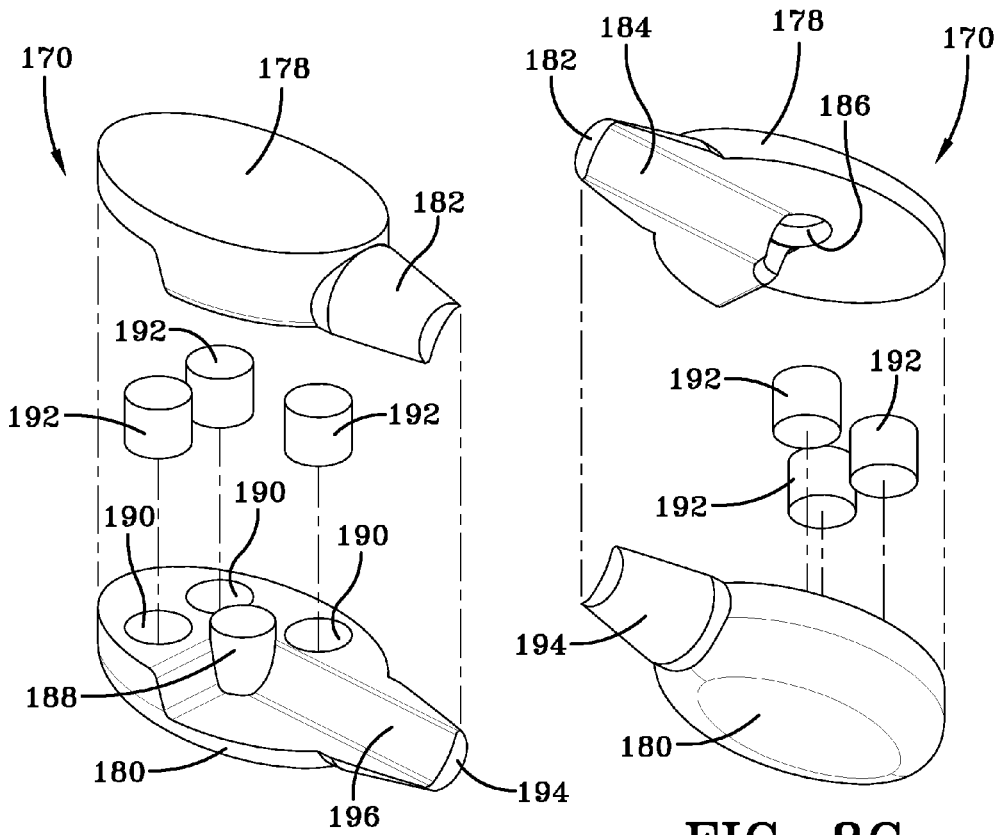


FIG-8B

FIG-8C

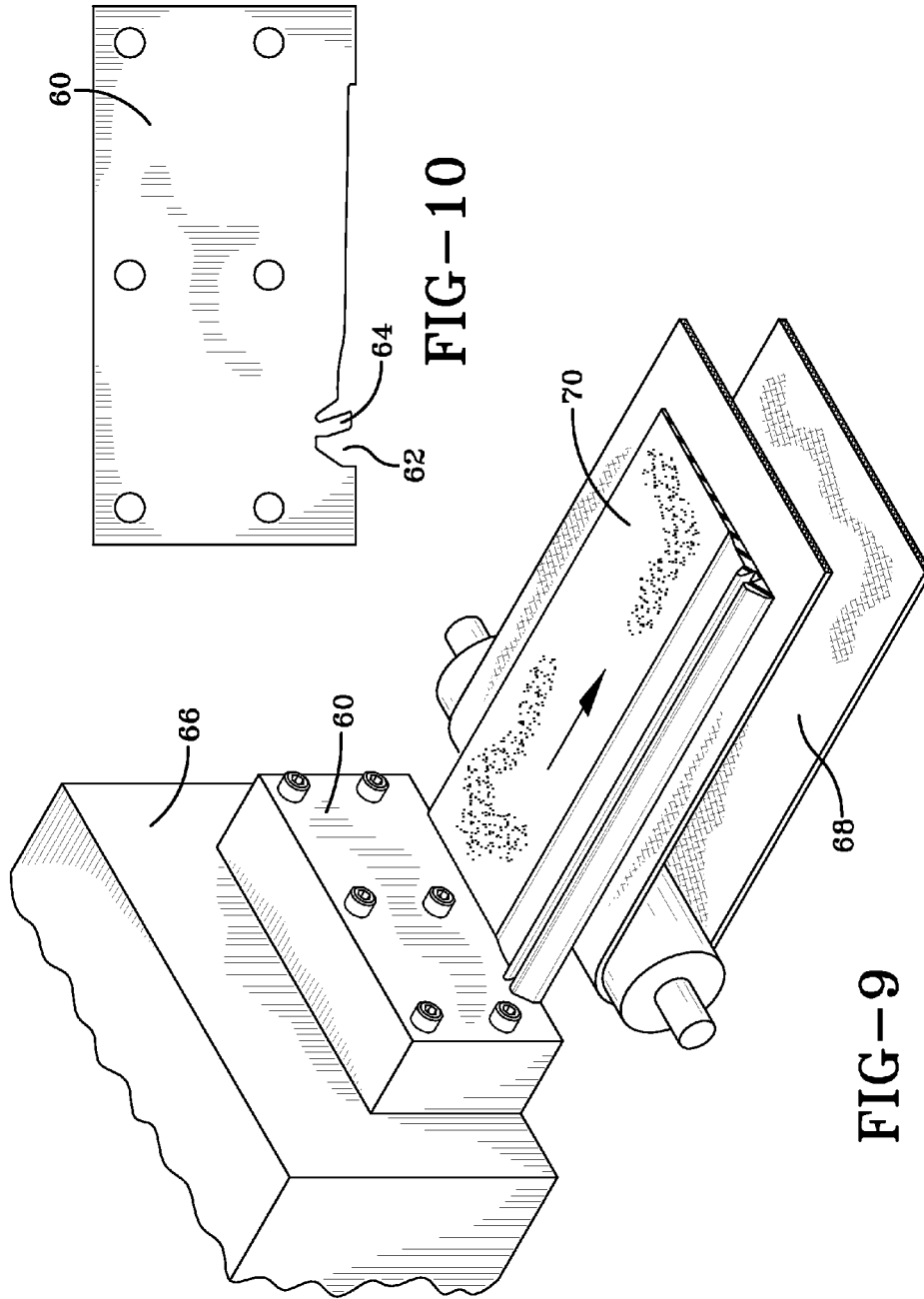


FIG-10

FIG-9

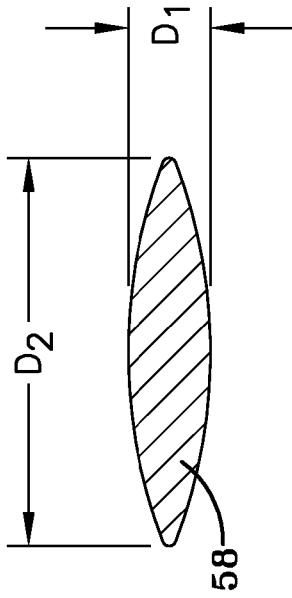


FIG-11

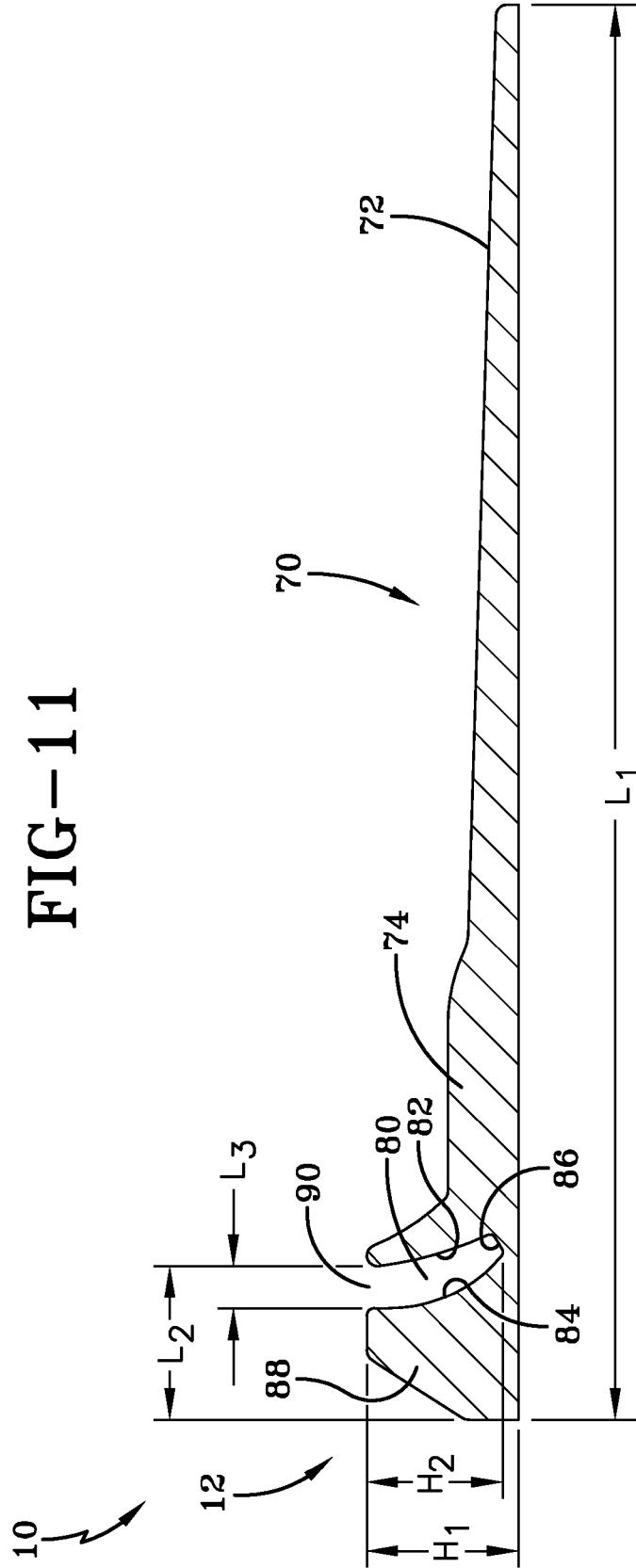


FIG-12

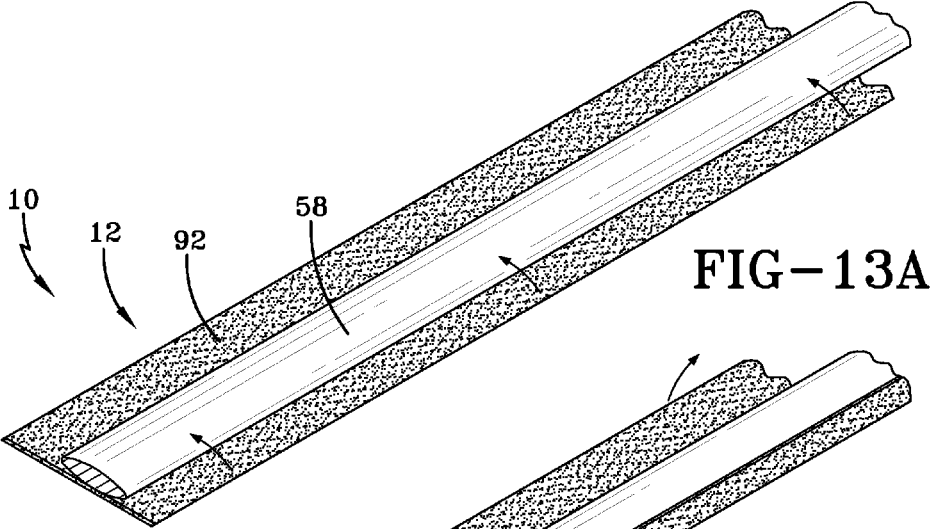


FIG-13A

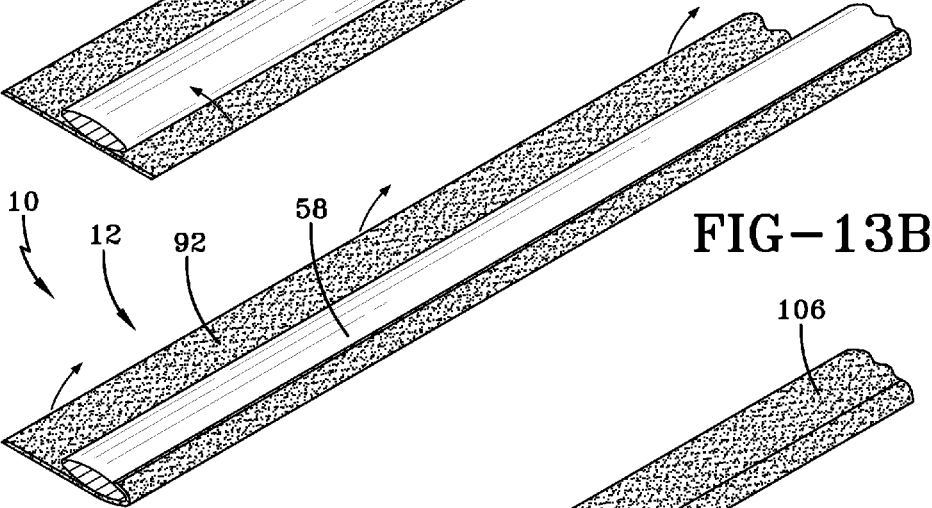


FIG-13B

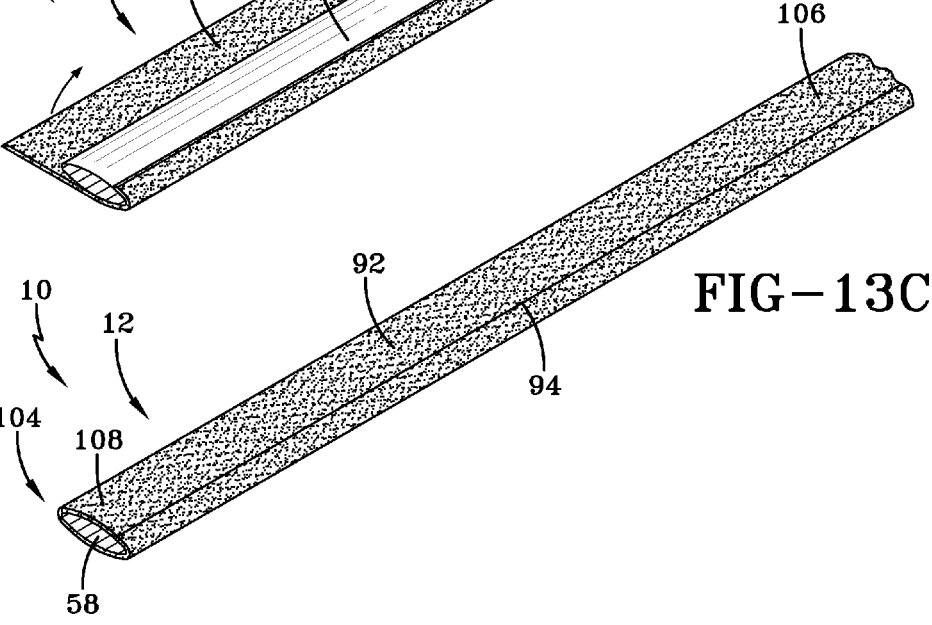
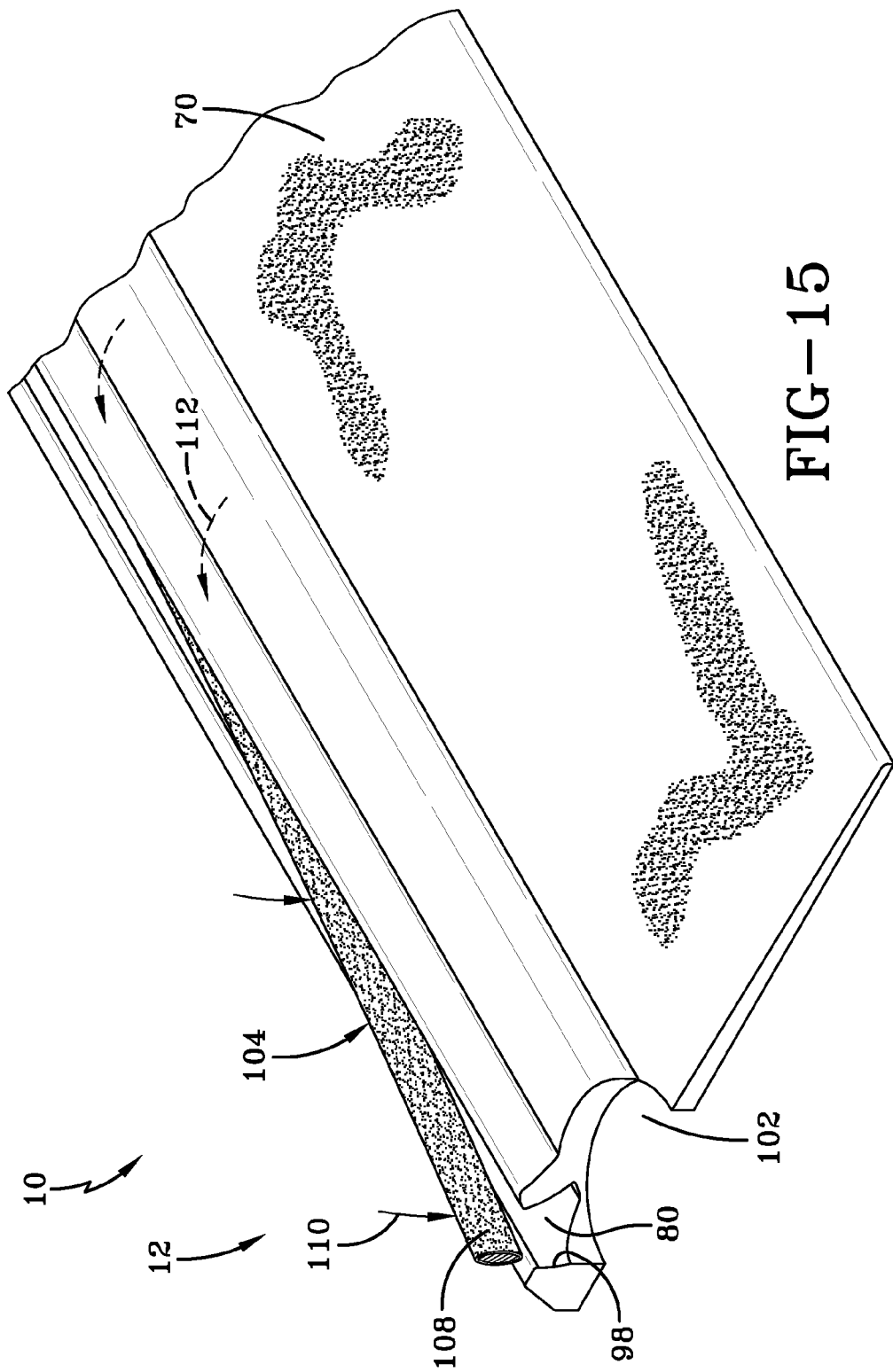


FIG-13C



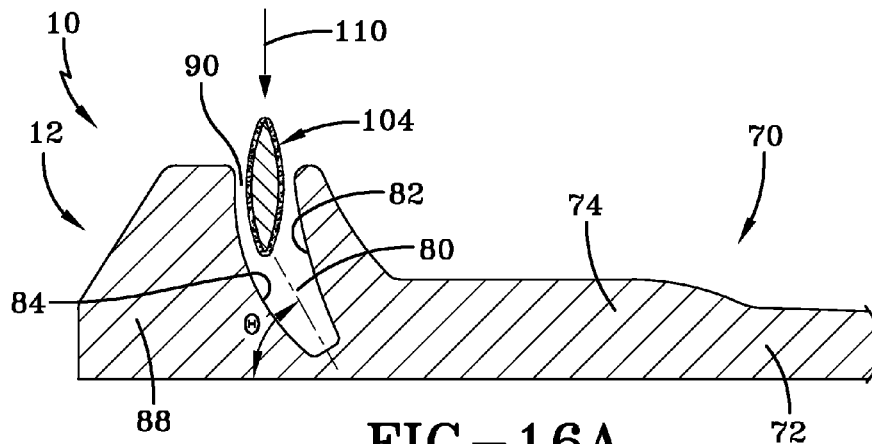


FIG-16A

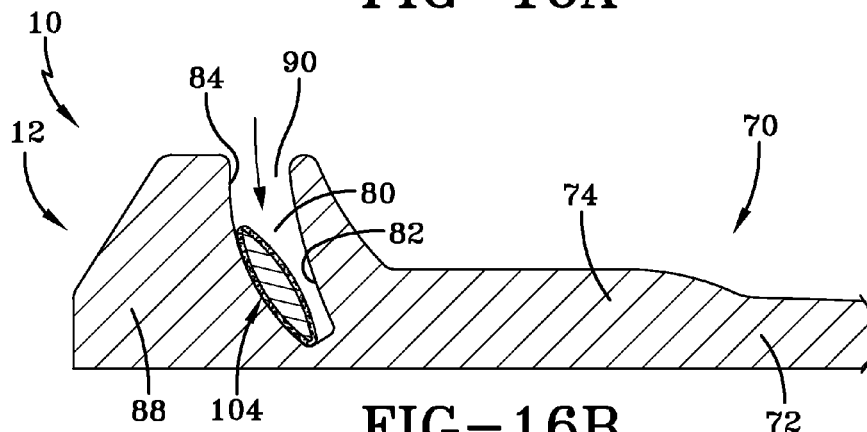


FIG-16B

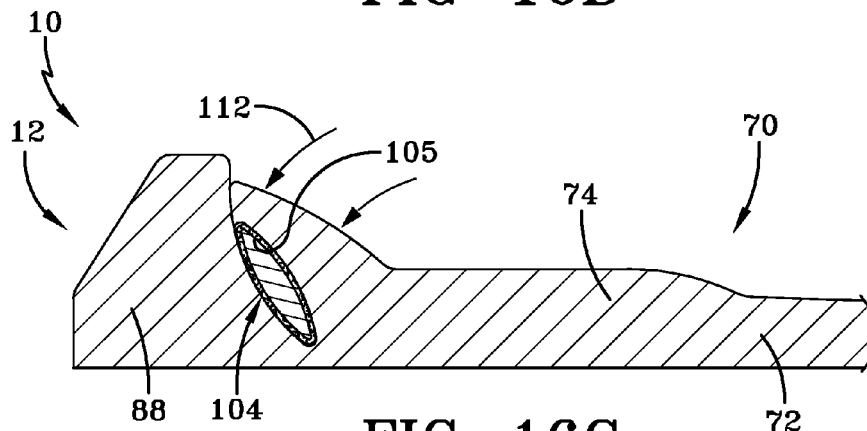


FIG-16C

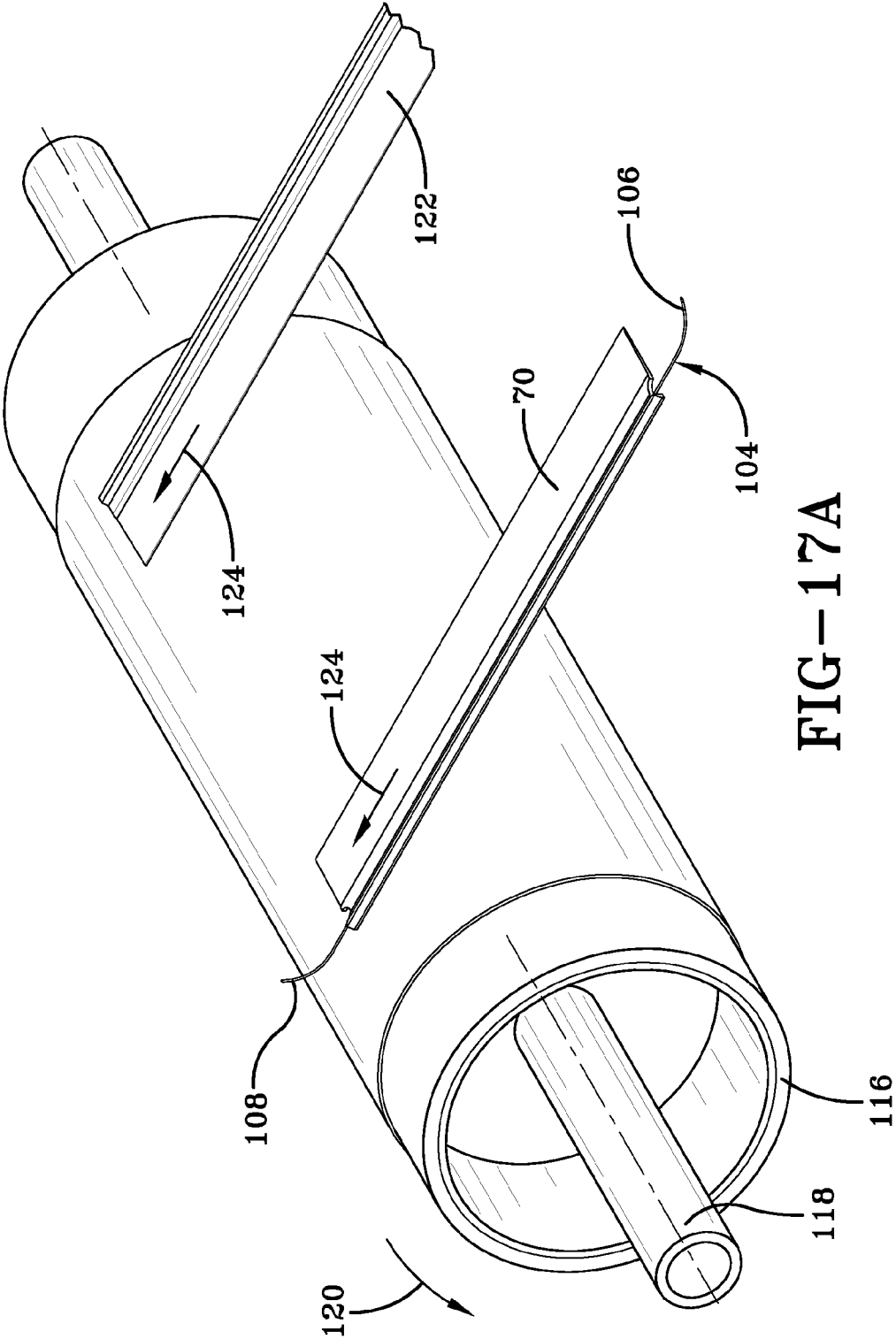


FIG-17A

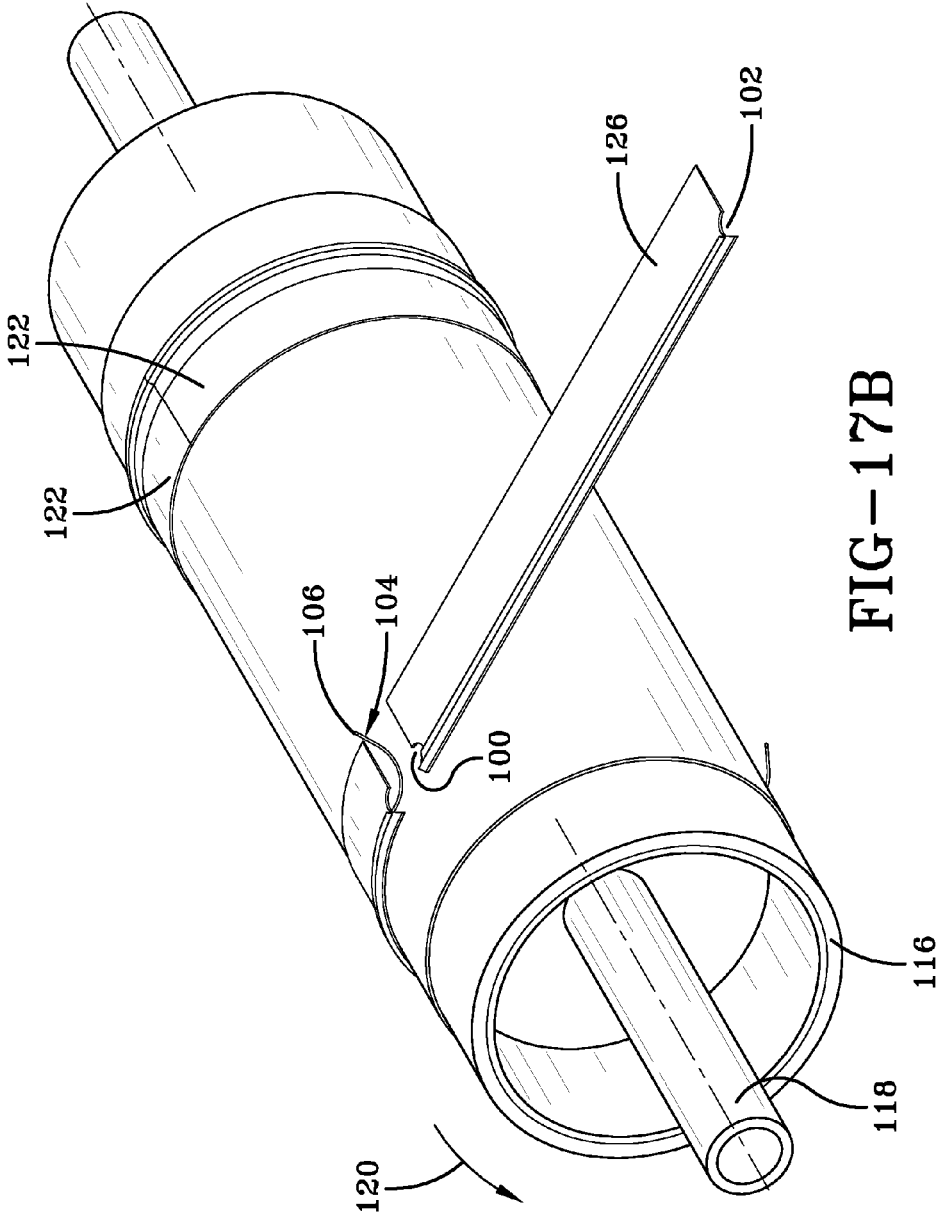


FIG-17B

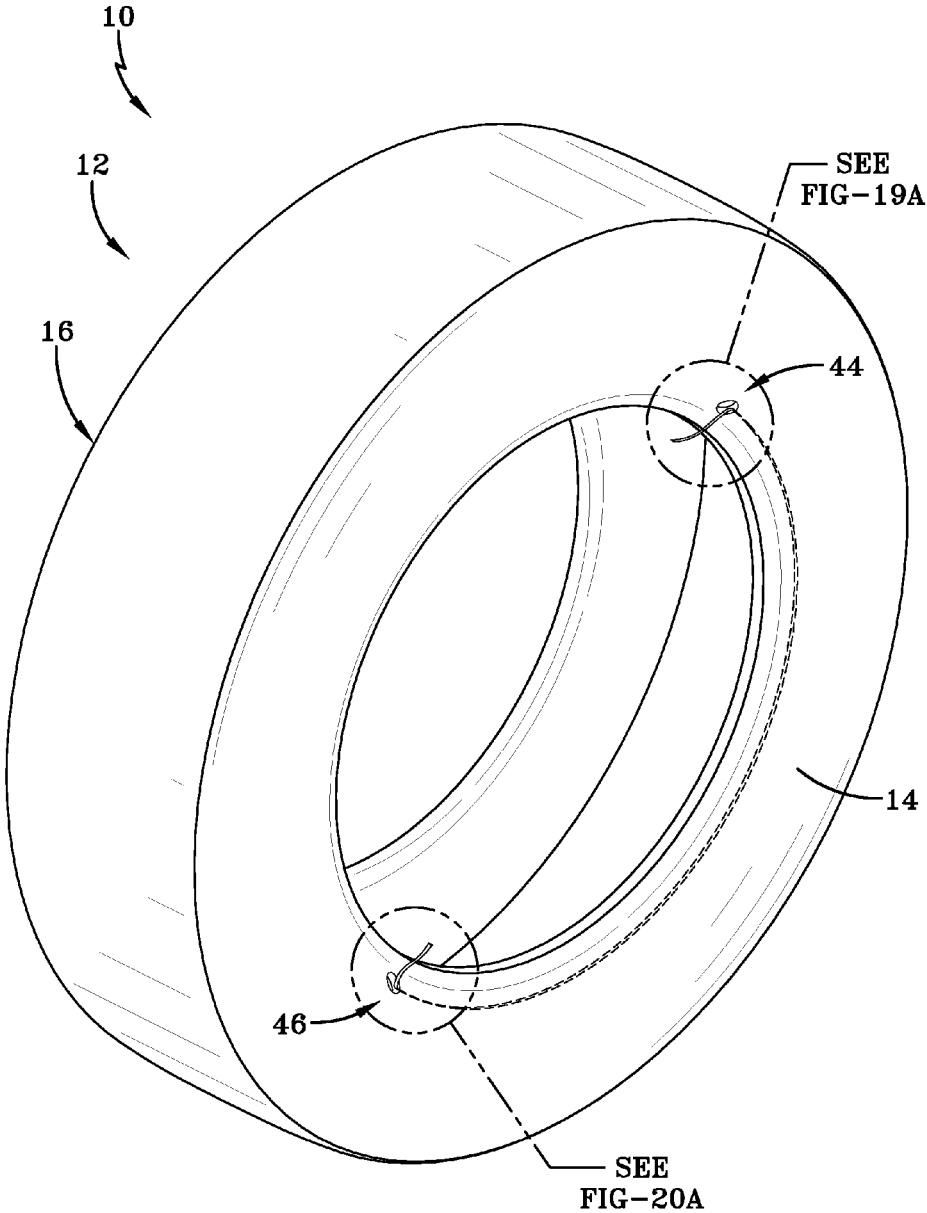


FIG-18

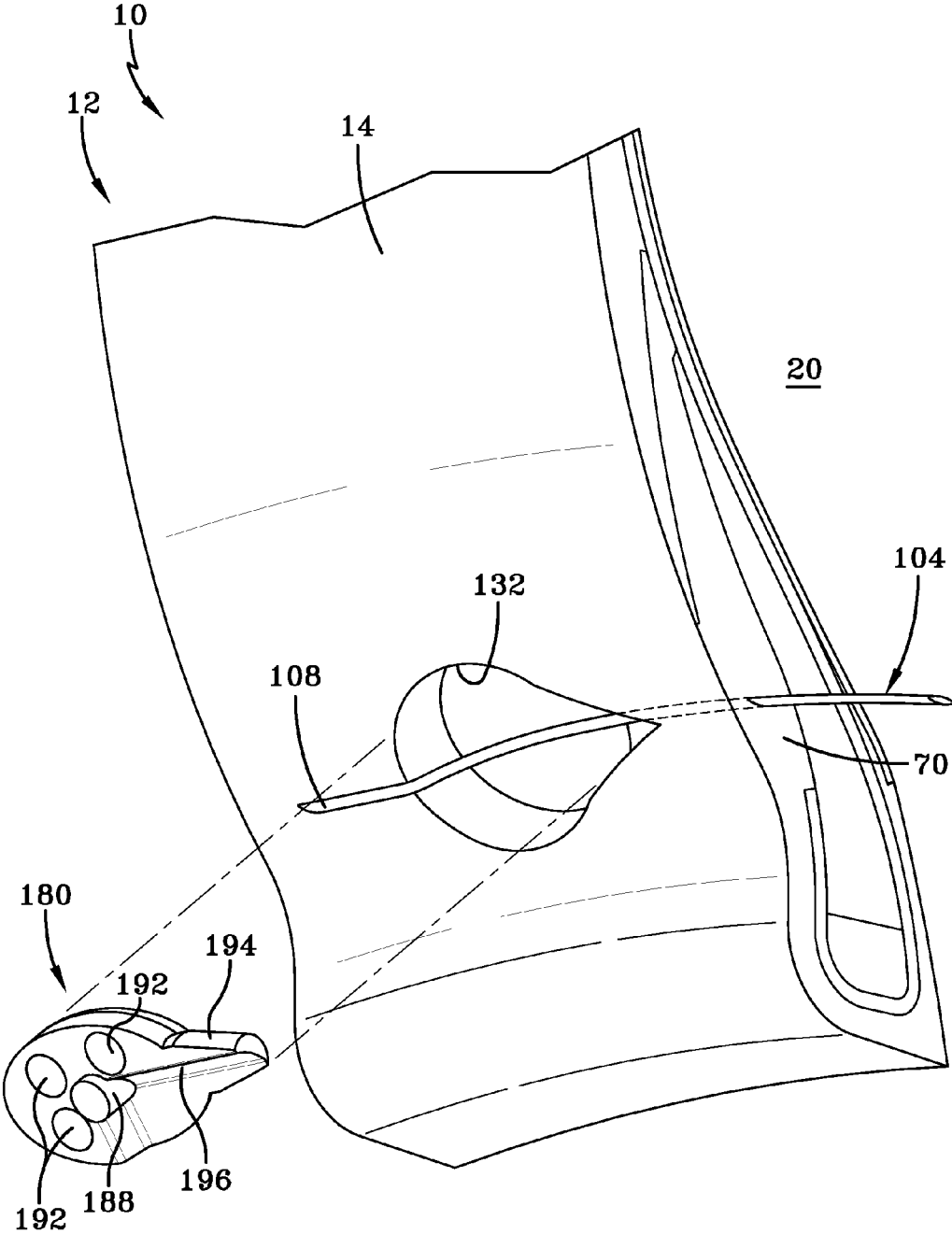


FIG-19A

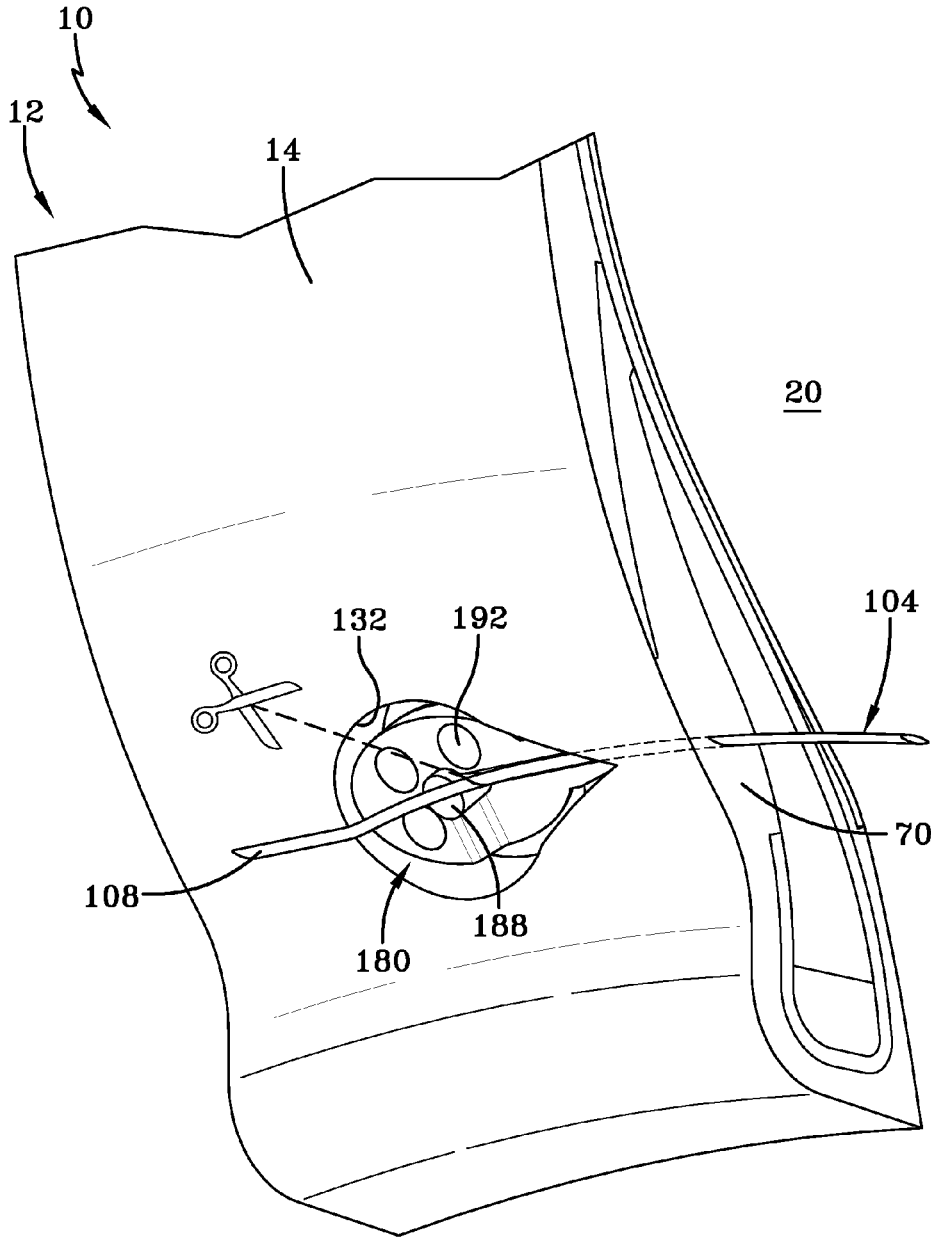


FIG-19B

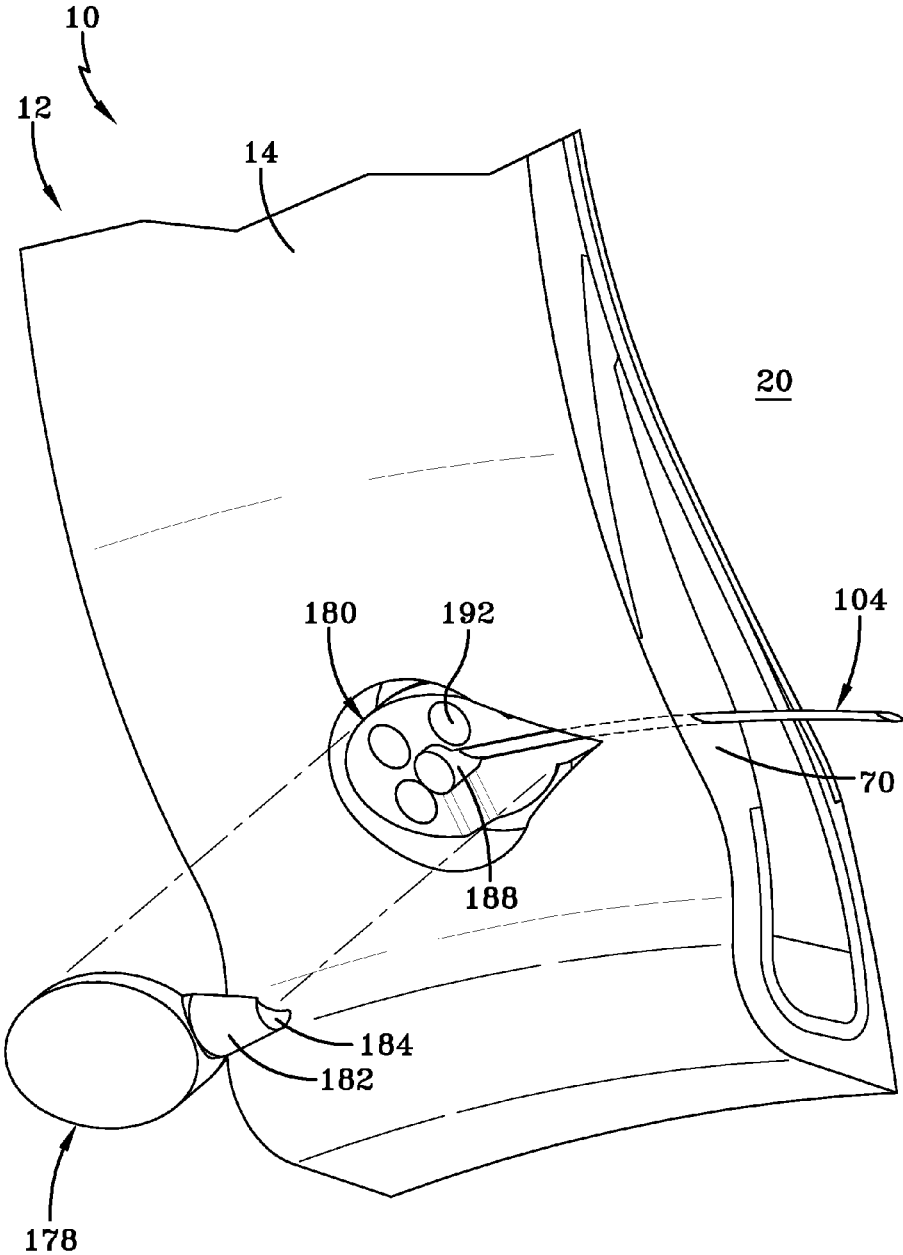


FIG-19C

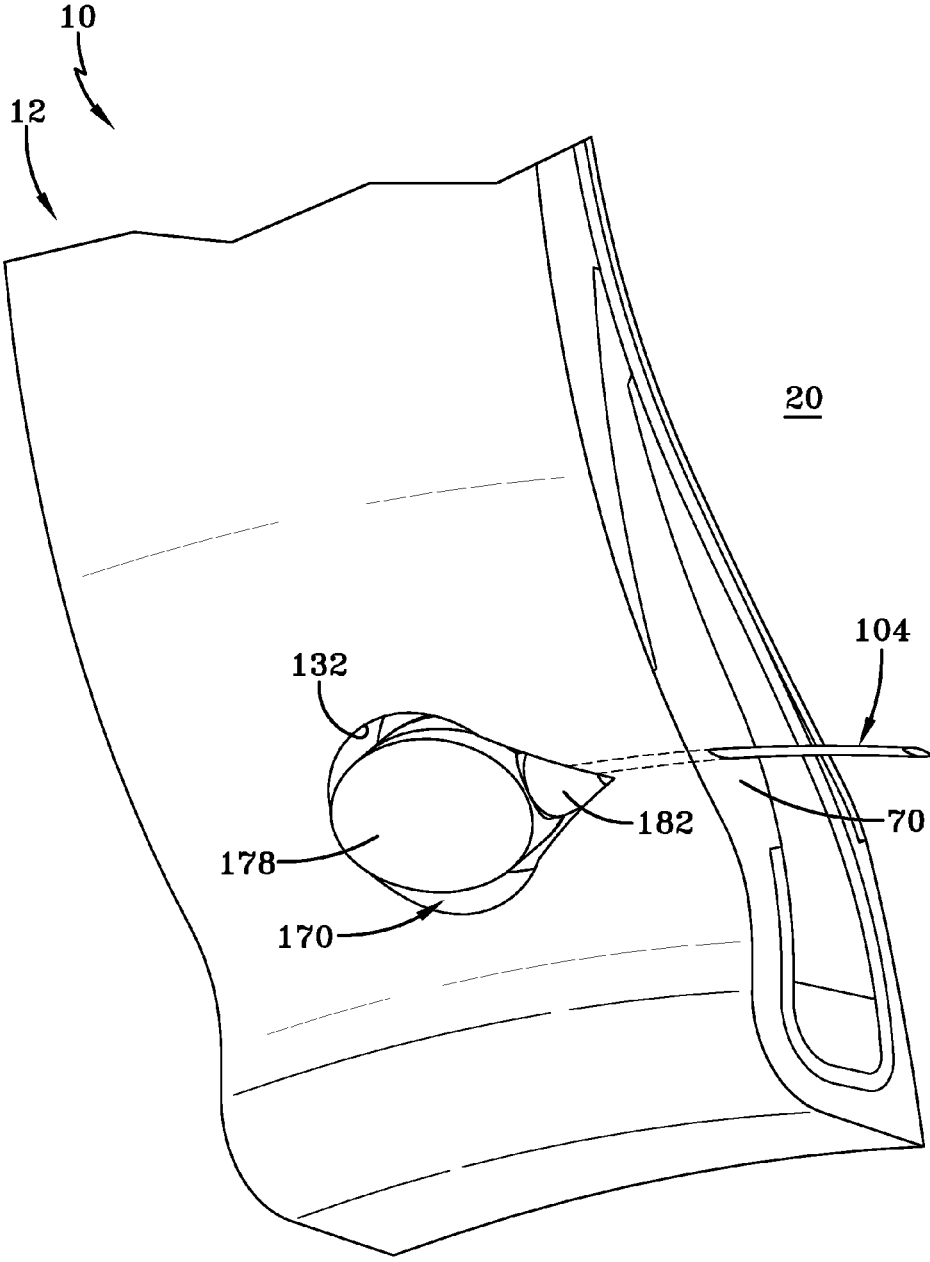


FIG-19D

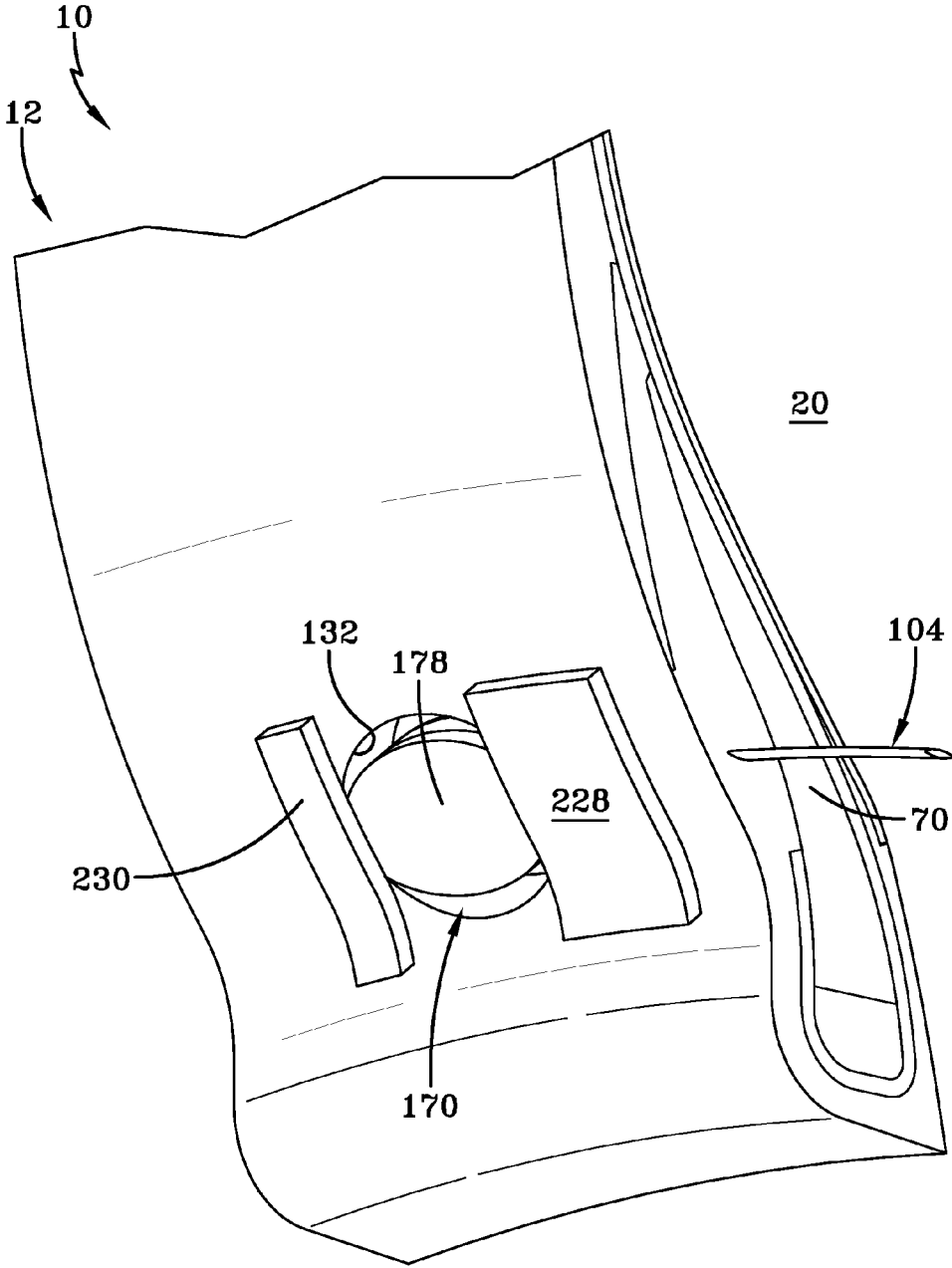


FIG-19E

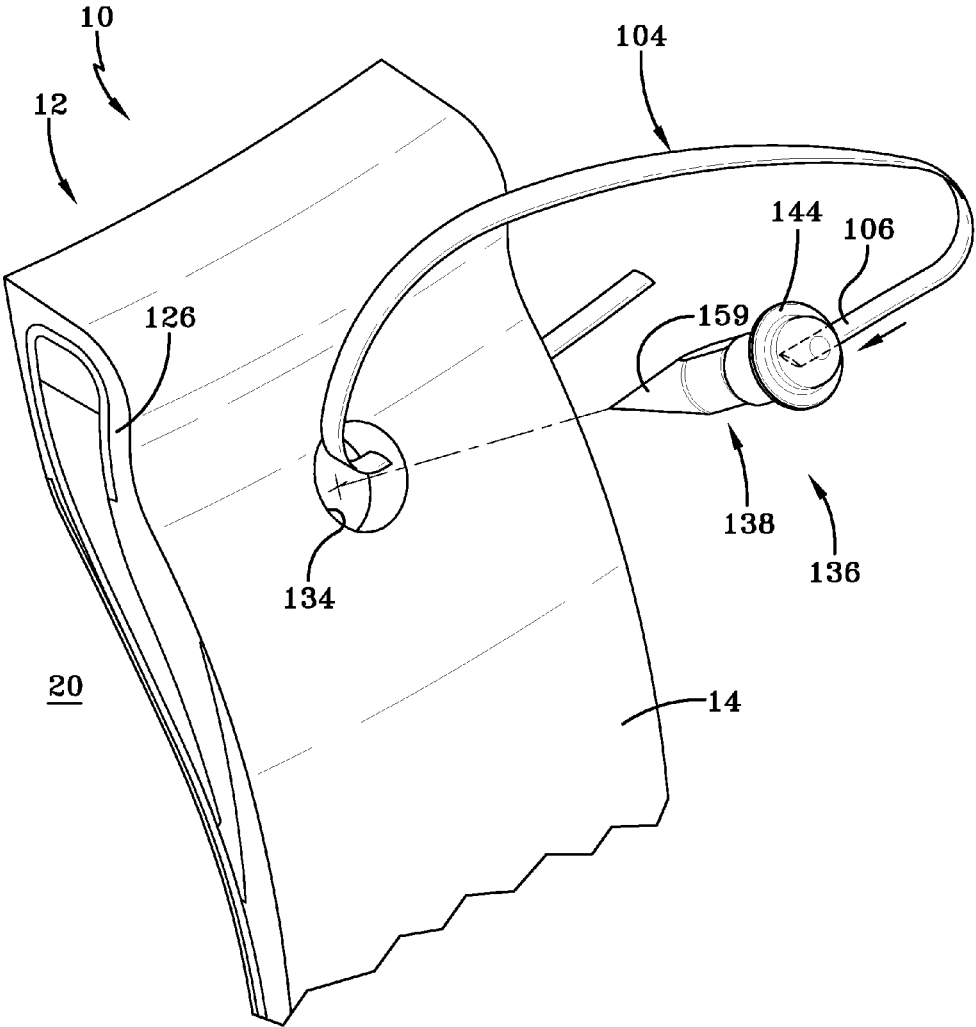


FIG-20A

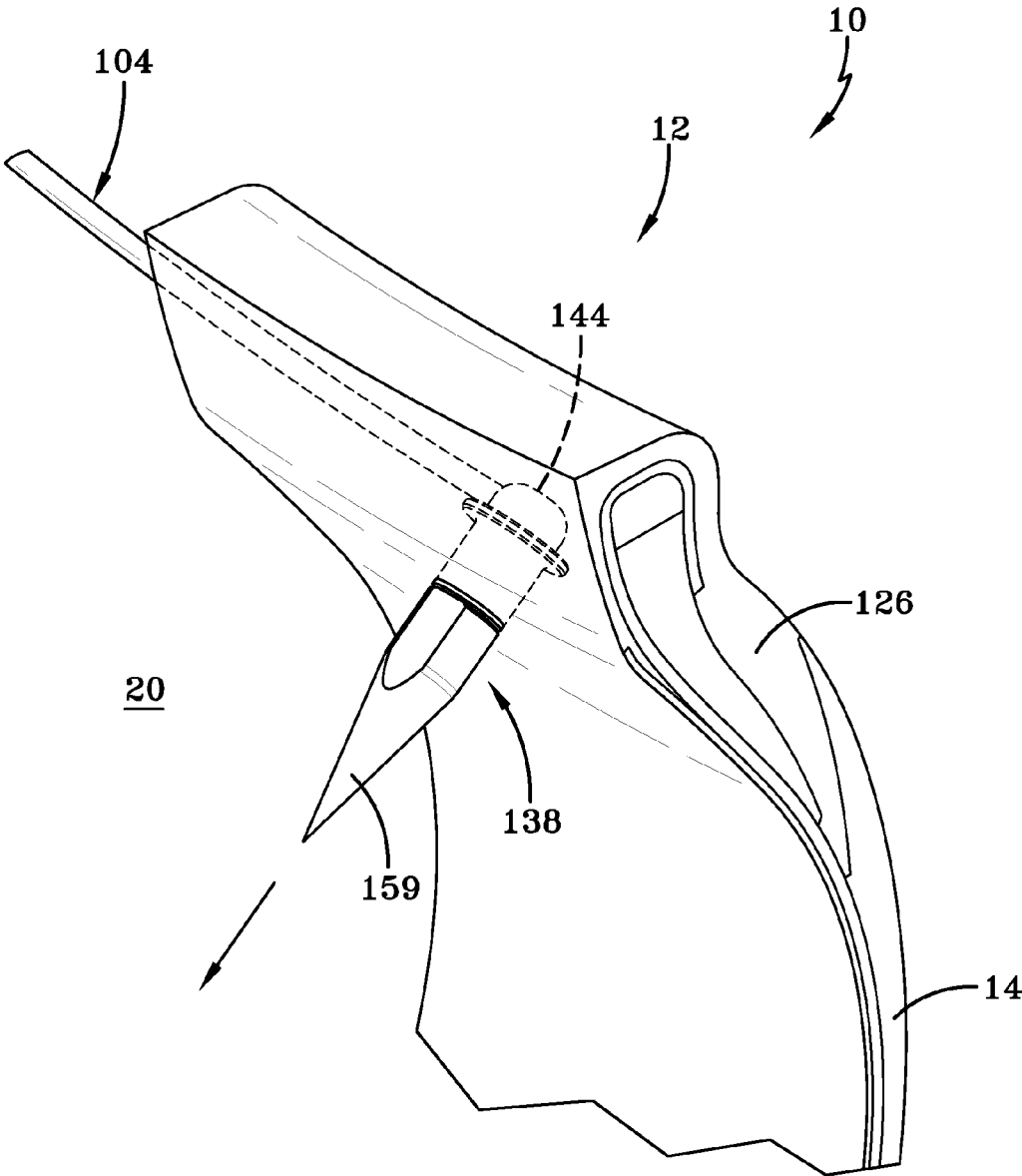


FIG-20B

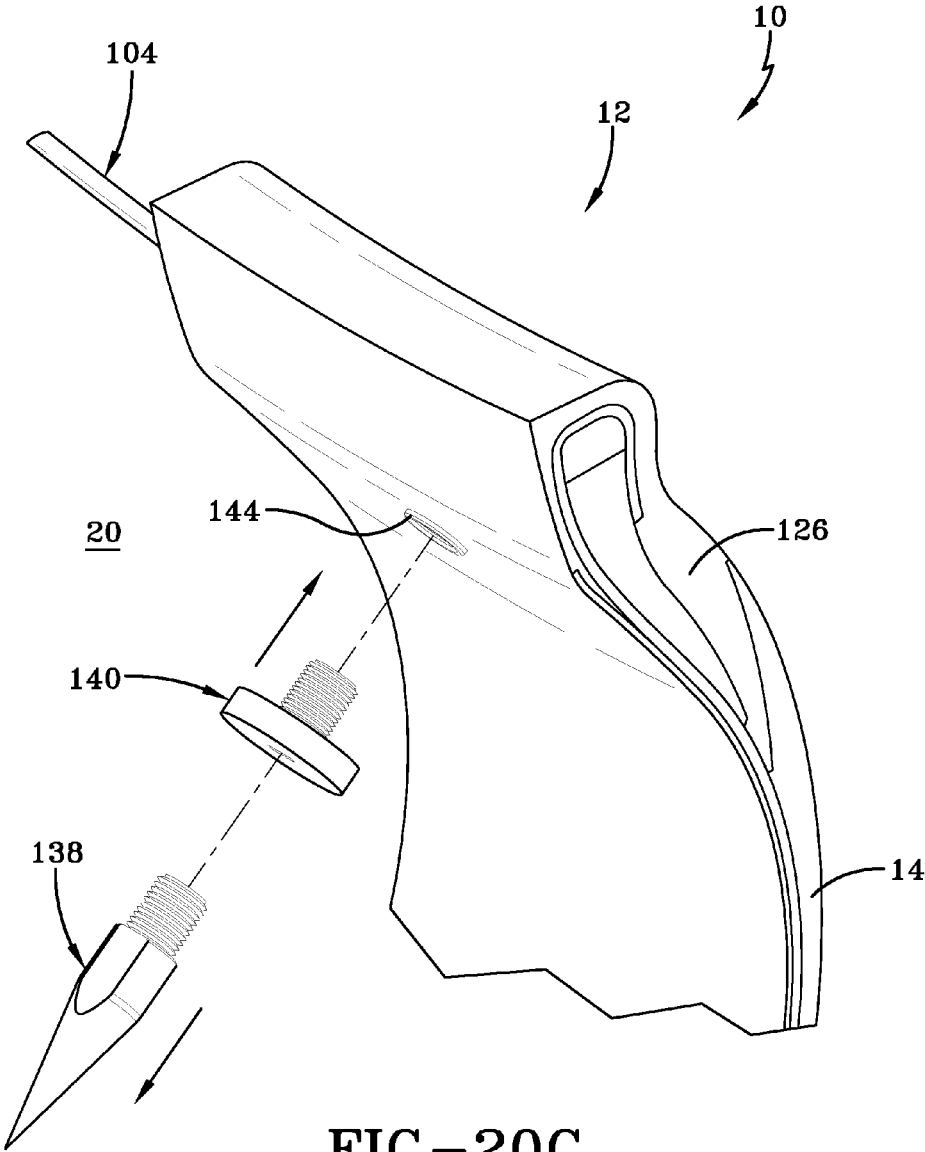


FIG-20C

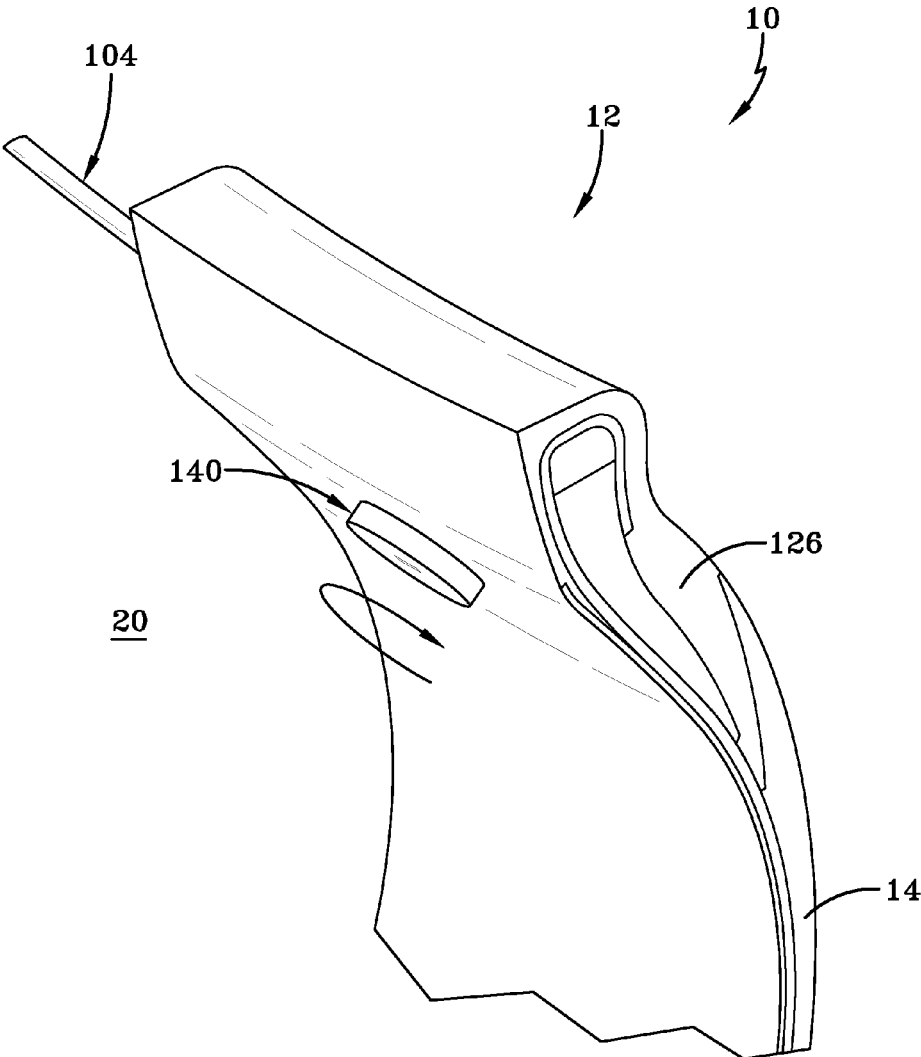


FIG-20D

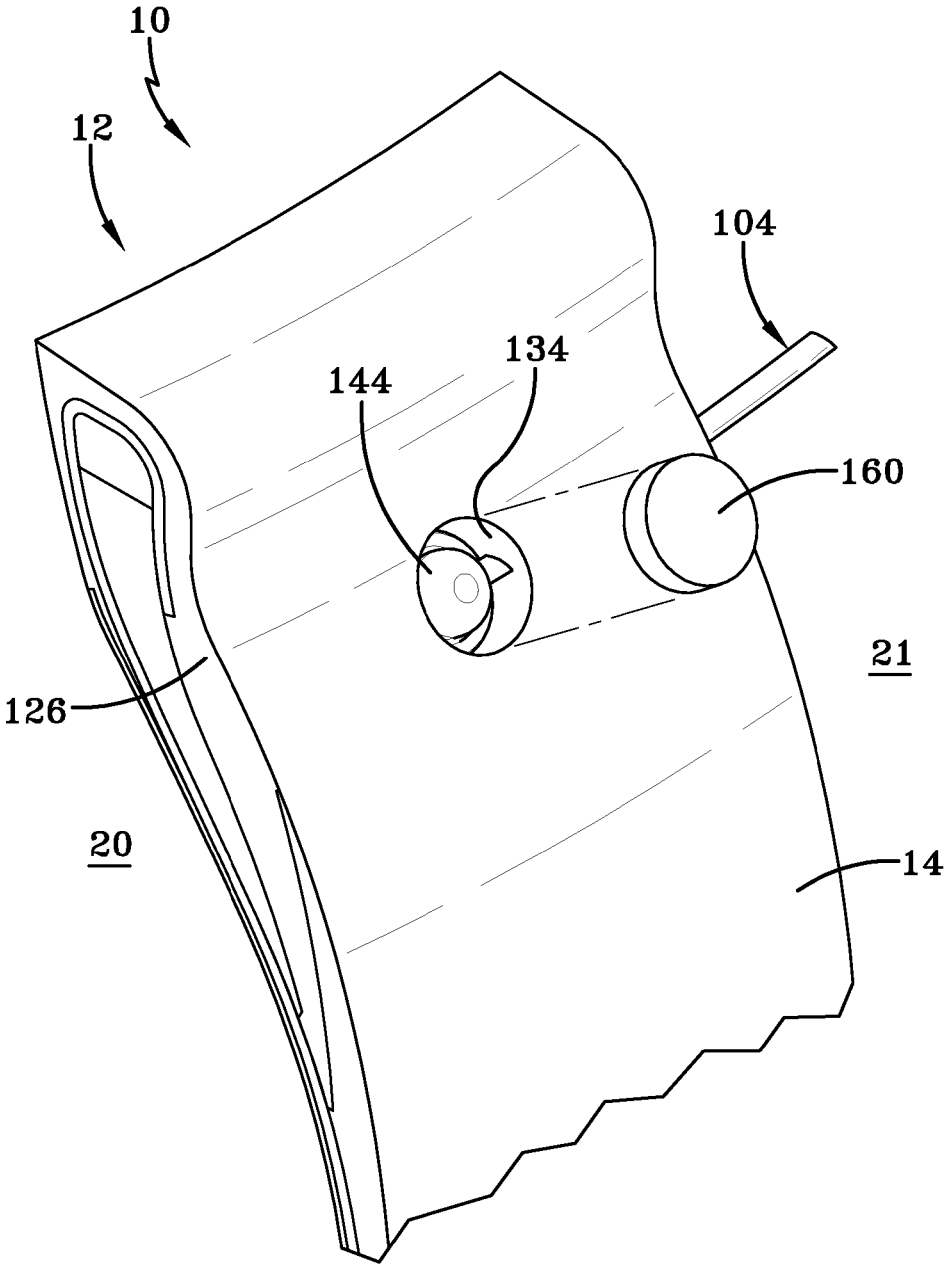


FIG-20E

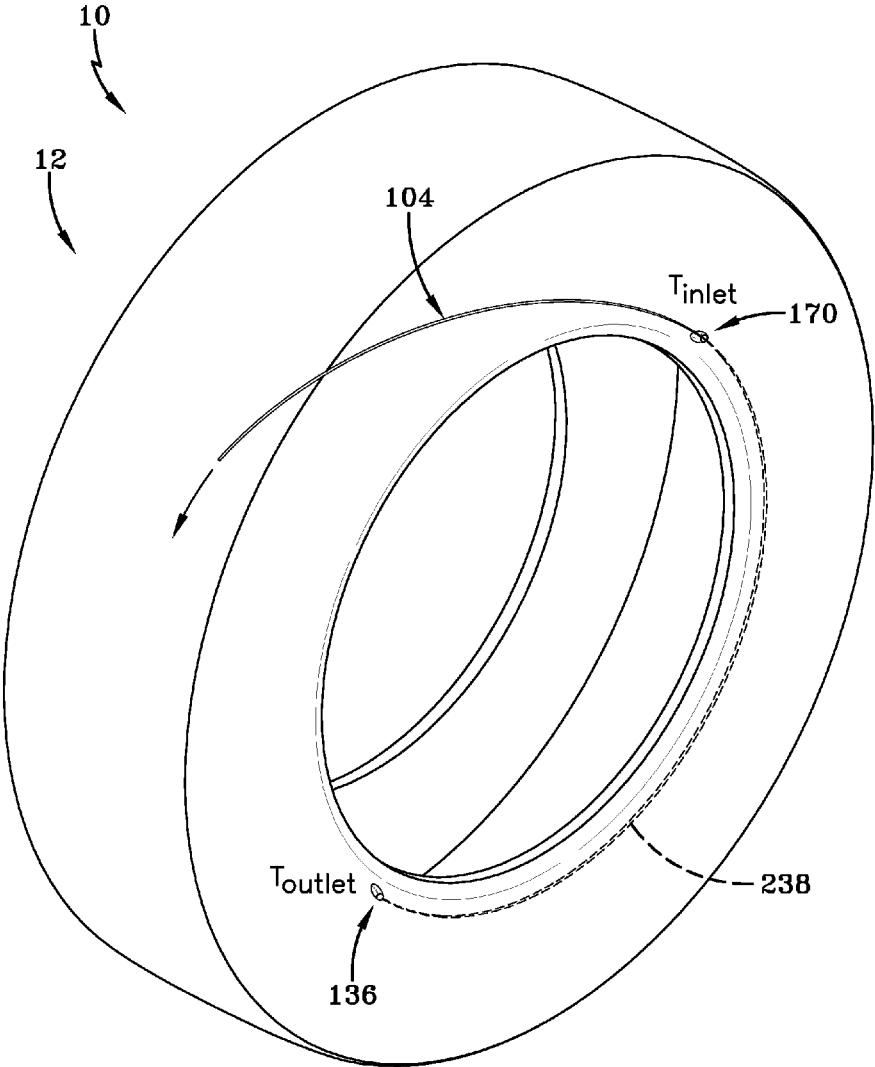


FIG-21

CONNECTOR SYSTEM AND AIR MAINTENANCE TIRE ASSEMBLY

FIELD OF THE INVENTION

[0001] The present invention relates generally to air maintenance tires and, more specifically, to a connector system for construction of an air maintenance pump assembly integrated into a tire.

BACKGROUND OF THE PRESENT INVENTION

[0002] Normal air diffusion reduces tire pressure over time. The natural state of tires is under inflated. Accordingly, drivers must repeatedly act to maintain tire pressures or they will see reduced fuel economy, tire life and reduced vehicle braking and handling performance. Tire Pressure Monitoring Systems have been proposed to warn drivers when tire pressure is significantly low. Such systems, however, remain dependant upon the driver taking remedial action when warned to re-inflate a tire to recommended pressure. It is a desirable, therefore, to incorporate an air maintenance feature within a tire that will re-inflate the tire in order to compensate for normal air diffusion over time without the need for driver intervention.

SUMMARY OF THE INVENTION

[0003] A connector system and tire assembly in accordance with the present invention includes 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 metallic connector assembly within outlet cavity, the connector assembly including a through-channel for conducting air flow communication between the air passageway within the flexible tire component and a chamber of the connector assembly.

[0004] According to another aspect of the connector system and tire assembly, the flexible tire component comprises a chafer component of the tire.

[0005] According to still another aspect of the connector system and tire assembly, the connector assembly includes a valve device for regulating a flow of air from the air inlet cavity to the tire cavity.

[0006] According to yet another aspect of the connector system and tire assembly, an elongate core strip is positioned within the air passageway of the tire flexible component. The through-channel of the connector assembly has a cross-sectional configuration to receive a free end of the core strip therethrough.

[0007] According to still another aspect of the connector system and tire assembly, the through-channel comprises a through-slit.

[0008] According to yet another aspect of the connector system and tire assembly, a metallic inlet connector assembly within the air inlet cavity includes an air inlet device for conducting air external to the tire into the air inlet cavity and a metallic outlet connector assembly within the air outlet cavity includes a valve device for regulating a flow of air from the air outlet cavity to the tire cavity.

[0009] According to still another aspect of the connector system and tire assembly, the flexible tire component comprises a chafer component of the tire.

[0010] According to yet another aspect of the connector system and tire assembly, a removable elongate core strip is positioned within the air passageway of the flexible tire component during a pre-cure build of the tire and withdrawn from the air passageway of a post-cure tire. A through-channel of both the inlet connector assembly and the outlet connector assembly each has a cross-sectional configuration to receive a respective free end of the core strip therethrough.

[0011] According to still another aspect of the connector system and tire assembly, each through-channel comprises a through-slit.

[0012] According to yet another aspect of the connector system and tire assembly, the metallic connector assembly is constructed of steel.

[0013] According to still another aspect of the connector system and tire assembly, the metallic connector assembly is constructed of titanium.

[0014] According to yet another aspect of the connector system and tire assembly, the metallic connector assembly is constructed of aluminum.

[0015] According to still another aspect of the connector system and tire assembly, the metallic connector assembly is constructed of stainless steel.

[0016] According to yet another aspect of the connector system and tire assembly, the metallic connector assembly is constructed of stainless steel and aluminum.

[0017] According to still another aspect of the connector system and tire assembly, the metallic connector assembly is constructed of stainless steel and titanium.

[0018] According to yet another aspect of the connector system and tire assembly, the metallic connector assembly is constructed of aluminum and titanium.

[0019] According to still another aspect of the connector system and tire assembly, the metallic connector assembly is constructed of stainless steel, titanium, and aluminum.

DEFINITIONS

[0020] “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.

[0021] “Asymmetric tread” means a tread that has a tread pattern not symmetrical about the center plane or equatorial plane EP of the tire.

[0022] “Axial” and “axially” means lines or directions that are parallel to the axis of rotation of the tire.

[0023] “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.

[0024] “Circumferential” means lines or directions extending along the perimeter of the surface of the annular tread perpendicular to the axial direction.

[0025] “Equatorial Centerplane (CP)” means the plane perpendicular to the tire’s axis of rotation and passing through the center of the tread.

[0026] “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.

[0027] “Groove” means an elongated void area in a tire wall that may extend circumferentially or laterally about the tire wall. The “groove width” is equal to its average width over its length. A groove is sized to accommodate an air tube as described.

[0028] “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.

[0029] “Lateral” means an axial direction.

[0030] “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.

[0031] “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.

[0032] “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.

[0033] “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.

[0034] “Peristaltic” means operating by means of wave-like contractions that propel contained matter, such as air, along tubular pathways.

[0035] “Radial” and “radially” means directions radially toward or away from the axis of rotation of the tire.

[0036] “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.

[0037] “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.

[0038] “Tread element” or “traction element” means a rib or a block element defined by having a shape adjacent grooves.

[0039] “Tread Arc Width” means the arc length of the tread as measured between the lateral edges of the tread.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] The invention will be described by way of example and with reference to the accompanying drawings in which:

[0041] FIG. 1 schematically shows a perspective front view of an example cured tire with an inlet, an outlet, and a channel for a 180 degree system in accordance with the present invention.

[0042] FIG. 2 schematically shows a side view of the example tire of FIG. 1.

[0043] FIG. 3A schematically shows a sectional view taken along line 3A-3A in FIG. 2 and schematically showing the inlet connector.

[0044] FIG. 3B schematically shows an enlarged sectional view of the inlet connector of FIG. 3A.

[0045] FIG. 4A schematically shows a sectional view taken along line 4A-4A in FIG. 2 and schematically showing the outlet connector.

[0046] FIG. 4B schematically shows an enlarged sectional view of the outlet connector of FIG. 4A.

[0047] FIG. 5A schematically shows a bottom perspective view of an outlet connector in accordance with the present invention.

[0048] FIG. 5B schematically shows a top perspective view of the outlet connector of FIG. 5A.

[0049] FIG. 5C schematically shows a top orthogonal view of the outlet connector of FIG. 5A.

[0050] FIG. 5D schematically shows a sectional view of the outlet connector taken along line 5D-5D in FIG. 5C.

[0051] FIG. 6A schematically shows a perspective view of screw punch for use with the present invention.

[0052] FIG. 6B schematically shows a sectional view taken along line 6B-6B in FIG. 6A.

[0053] FIG. 7A schematically shows a front perspective view of a plug in accordance with the present invention.

[0054] FIG. 7B schematically shows a rear perspective view of the plug of FIG. 7A.

[0055] FIG. 7C schematically shows a sectional view taken along line 7C-7C in FIG. 7B.

[0056] FIG. 8A schematically shows a top perspective view of an inlet connector in accordance with the present invention.

[0057] FIG. 8B schematically shows a top exploded perspective view of the inlet connector of FIG. 8A.

[0058] FIG. 8C schematically shows a bottom exploded perspective view of the inlet connector of FIG. 8A.

[0059] FIG. 9 schematically shows a perspective view of a basic chafer strip extruder and conveyor for use with the present invention.

[0060] FIG. 10 schematically shows a detail view of the chafer strip die.

[0061] FIG. 11 schematically shows a sectional view of an example silicone core in accordance with the present invention.

[0062] FIG. 12 schematically shows a sectional view of an example extruded chafer strip in accordance with the present invention.

[0063] FIG. 13A schematically shows a detailed view of an example silicone core strip and an example soft rubber gum strip.

[0064] FIG. 13B schematically shows a detailed view of the example silicone core strip with a partially folded over soft rubber gum strip.

[0065] FIG. 13C schematically shows a detailed view of the example silicone core strip with a soft rubber gum strip folded about it.

[0066] FIG. 14 schematically shows an example chafer strip with holes at locations for the inlet and outlet connectors.

[0067] FIG. 15 schematically shows an enlarged perspective view of the silicone core strip of FIG. 13C being assembled into the chafer strip of FIG. 14.

[0068] FIG. 16A schematically shows a sectional view of the coated silicone core strip of FIG. 13C being inserted into the chafer strip of FIG. 14.

[0069] FIG. 16B schematically shows a sectional view of the coated silicone core strip of FIG. 13C fully inserted into the chafer strip of FIG. 14.

[0070] FIG. 16C schematically shows a sectional view of the coated silicone core strip of FIG. 13C fully inserted into, and enclosed within, the chafer strip of FIG. 14.

[0071] FIG. 17A schematically shows a perspective view of tire build drum with an assembled 180 degree core/chafer strip and a conventional chafer strip being applied.

[0072] FIG. 17B schematically shows a perspective view of a tire build drum with a conventional 180 degree chafer strip being applied to abut the 180 degree core/chafer strip.

[0073] FIG. 18 schematically shows a perspective front view of a formed green with inlet and outlet connectors as well as two extending ends of an inserted silicone core strip.

[0074] FIG. 19A schematically shows an enlarged perspective view of a bottom half member of the inlet connector being inserted into a cavity in a sidewall of the green tire under the silicone core strip.

[0075] FIG. 19B schematically shows an enlarged perspective view of the bottom half member of FIG. 19A positioned within the cavity.

[0076] FIG. 19C schematically shows an enlarged perspective view of a top half member of the inlet connector being inserted into the cavity in the sidewall of the green tire over the silicone core strip.

[0077] FIG. 19D schematically shows an enlarged perspective view of the inlet connector fully inserted in the cavity in the sidewall of the green tire over the silicone core strip.

[0078] FIG. 19E schematically shows an enlarged perspective view of the inlet connector fully inserted into the cavity in the sidewall of the green tire over the silicone core strip with two rubber strips placed over the cavity prior to curing.

[0079] FIG. 20A schematically shows an enlarged perspective view of a screw punch and outlet connector being forced through the sidewall into the cavity with the silicone core strip inserted into the sidewall and the outlet connector.

[0080] FIG. 20B schematically shows an enlarged perspective view of the inner side of the sidewall with the screw punch and outlet connector fully penetrating the sidewall.

[0081] FIG. 20C schematically shows an enlarged perspective view of the inner side of the sidewall with the screw punch removed from the outlet connector and the plug ready to be attached to the outlet connector.

[0082] FIG. 20D schematically shows an enlarged perspective view of the inner side of the sidewall with the plug attached to the outlet connector.

[0083] FIG. 20E schematically shows an enlarged perspective view of the outer side of the sidewall with a rubber cap for closing the outlet opening in the outer sidewall.

[0084] FIG. 21 schematically shows the silicone core strip being removed after curing.

DETAILED DESCRIPTION OF EXAMPLES OF THE PRESENT INVENTION

[0085] Referring initially to FIGS. 1, 2, 3A, and 3B, an example air maintenance assembly and tire system 10 is shown. The system 10 may incorporate an air maintenance apparatus with a tire for the purpose of maintaining air pressure within the tire at a desired level without operator intervention. The example system 10 may include a pneumatic tire 12 having a pair of sidewall components 14, 16 and a tread 18 enclosing a tire cavity 20. The sidewalls 14, 16 may extend from a pair of inextensible tire beads 22, 24 to the tread 18. Each sidewall 14, 16 may have an apex component 26 disposed radially adjacent each bead 22, 24 and a chafer component 28 surrounding each bead. The example tire 12 may mount to a wheel 36 and be seated on a rim surface 40. An air maintenance assembly 42 may be provided within one (FIG. 3A) 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.

[0086] In accordance with the present invention, the air maintenance assembly 42 may incorporate a thin hollow tube within a flexible tire component, such as the chafer 28, during tire construction. 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.

[0087] With reference to FIGS. 9-12, a silicone core strip 58 may be formed by means of die having a profiled orifice therethrough (not shown). The orifice may be elongate and generally lens shaped in section with the extruded strip 58 of like sectional geometry (FIG. 11). The lens shape may have a dimension of, by way of example without limitation, 2.7 mm width $D_2 \times 0.5$ mm thickness D_1 . While the example composition of the strip 58 may be silicone, other materials such as cable or monofilament may be used. The die may be affixed to a basic extruder of conventional configuration and may deposit a formed core strip 58 on a conveyer belt moved by drive roller. The length of the strip 58 may be predetermined.

[0088] As shown in FIGS. 9 and 10, a chafer strip 70 may be formed by an extrusion die 60 affixed to an extruder 66 and deposited on roller 68. The die 60 may form a chafer forming opening 62 along a bottom side and a downward projection finger 64 projecting into the opening 62. FIG. 12 shows a sectional view of the extruded chafer strip 70. The chafer strip 70 widens in section from a low width or thinner end region 72 to a stepped wider or thicker region 74 to a wider or thicker opposite region 88. The die finger 64 may form an incut, arching chafer channel or tube 80 extending the length of the chafer strip 70 and defined by channel sidewalls 82, 84 and bottom wall 86. The channel may be open-ended initially, as shown at 90. Example dimensions, as seen in FIG. 12, may be within a range of $L_1=25$ mm to 100 mm; $L_2=2$ mm to 5 mm; $L_3=0.5$ mm to 1.5 mm; $H_1=4$ mm to 6 mm; and $H_2=3.5$ mm to 5.5 mm. However, the chafer strip dimensions L_1, L_2, L_3, H_1, H_2 may be varied to suit specific tire sizing needs and tire construction characteristics. Alternatively, the silicone strip 58 may also be molded instead of extruded.

[0089] A flexible tire component, as shown in FIG. 12, such as a chafer segment, may have a groove 80 defined by groove lips 82, 84 that angle inwardly from top to bottom to a bottom groove wall 86. The groove 80, formed within an axially outward thicker side 88 of the chafer strip 80, may open at the groove opening 90. The groove 80 may be formed within the chafer strip 80 as a result of angles extending axially outward from the opening 90 to the bottom wall 86 at an acute angle θ , which may be within a range of -20 degrees to $+20$ degrees.

[0090] As shown in FIGS. 12A-12C, the silicone strip 58 may be enveloped within an outer sheath or covering 92 formed of rubber gum or other suitable material. The rubber gum sheath 92 may be folded over the silicone strip 58 to form an overlap seam 94 to enclose the silicone strip and thus form therewith a sheathed silicone strip assembly 104. The strip assembly 104 may be used to form peristaltic tube or channel within a green tire during green tire assembly construction. The strip assembly 104 may form within a green tire component, such as chafer 28, a core air passageway which, once the silicone strip is removed, may integrally form a peristaltic tube/channel within and enclosed by that tire component. The

angled groove **80** may be formed within the chafer strip **70** as a slot, with the lips **82**, **84** in a close opposed relationship.

[0091] The groove **80** may be opened to receive the strip assembly **104** by an elastic spreading apart of groove lips **82**, **84**. Thereafter, the assembly **104** may be inserted downward into the groove **80** until reaching a position adjacent to the bottom wall **86**. A release of the lips **82**, **84** may allow the lips to elastically resume their close opposed relationship. The lips **82**, **84** may be then stitched together in a rolling operation wherein a roller (not shown) may press the lips **82**, **84** into the closed relationship shown in FIGS. **14**, **15**, and **16A-16C** thereby sealing within the chafer strip **28** by folding the chafer strip **70** over the top, as shown in FIG. **16C**. The angle θ of the channel **80** with respect to a bottom surface of the chafer strip **70** may completely enclose the silicone strip assembly **104** within the tire component (e.g. the chafer **28**) thereby entirely surrounding the silicone strip assembly with the chafer strip material.

[0092] With reference to FIGS. **13-16C**, the channel **80** may define the channel of a peristaltic pump assembly within a tire chafer **28** and generally extend from a chafer strip end **96** to the other chafer strip end **98**. The uncured/green chafer strip **70** may be cut at a given length depending on the pump length that is desired for the cured tire **12**. Formed within each end **86**, **98** of the chafer **70** by a punching operation or cutting operation may be enlarged diameter circular holes **100**, **102**. The holes **100**, **102** may be adjacent the ends of the channel **80** and may be sized to accommodate receipt of a peristaltic pump inlet device and a peristaltic outlet device. The lips **82**, **84** of the chafer channel **80** may be pulled apart. The wrapped silicone strip assembly **104** may be inserted at direction arrow **110** into the channel **80** as shown in FIGS. **16A-16C** until the assembly is adjacent and in contact with the lower wall **86** of the channel **80** (FIG. **16B**). Thereupon, the silicone strip assembly **104** may be enclosed by the chafer strip **70** by a folding over of the chafer lip flap **82** in direction **112** (FIG. **16C**).

[0093] The channel **80** may thus be closed and subsequently stitched in the closed position (FIG. **16C**) by a pair of pressure contact rolls (not shown). So enclosed, the silicone strip assembly **104** may preserve/maintain the geometry of the channel **80** from a green tire build until after a tire cure, when the assembly is subsequently removed. The silicone strip assembly **104** may be dimensioned such that assembly ends **106**, **108** may extend free from the uncured chafer strip **70** and the channel **80**, and may further extend a distance beyond the punched holes **100**, **102** at opposite ends **106**, **108** of the chafer strip.

[0094] Referring to FIGS. **17A**, **17B** & **18**, a green tire building station is depicted to include a build drum **116** rotatable about an axial support **118**. The chafer strip **70** containing the silicone strip assembly **104** and an opposite chafer strip **122**, that may (not shown) or may not (shown in FIGS. **17A** & **17B**) incorporate a strip assembly, may be positioned along opposite sides of the build drum **116** in a direction **124** for an initial 180 degree chafer build. The chafer strip **70** may thus combined with a normal chafer strip **126** to complete the 360 degree circumference. The normal chafer strip **126** may thus be applied to the build drum **116** in axial alignment with and the abutting the chafer strip **70** to complete a 360 degree chafer construction on the build drum.

[0095] The opposite side of the build drum **116** may receive two 180 degree normal strips **122** in abutment to complete the chafer build on that side of the build drum. It will be noted that

the chafer strip **70** may contain the silicone strip assembly **104** while the abutting strip **126** does not. However, if desired, both of the chafer strips **70**, **126** as well as one or both of the strips **122** may be configured to contain a silicone strip assembly **104** to create a 360 degree peristaltic pump tube on one side or both sides of the green tire **12**. The example of FIGS. **17A** & **17B** shows a pumping tube of 180 degrees in one chafer strips only (e.g., **70**). In FIG. **17B**, it will be noted that the normal chafer strip **126** is configured to complement the construction of the chafer strip **70** with the holes **100**, **102**. The circular holes **100**, **102** may be at opposite ends of the complementary strip **126**. When abutted against the chafer strip **70**, the holes **100**, **102**, create 180 degree opposite cavities **132**, **134**, as seen in FIG. **18**.

[0096] The end **106** of the silicone strip assembly **104** will hereafter be referred to as the "outlet end portion" extending through the outlet cavity **134** and the end **108** hereafter referred to as the "inlet end portion" of the silicone strip assembly extending through the inlet cavity **132**. FIG. **18** illustrates the 180 degree extension of the silicone strip assembly **104** and FIGS. **19A-19E**, show the relative location of the silicone strip assembly **104** to the tire bead and apex components **22**, **26**. FIG. **19A** shows the inlet cavity **132** and silicone core assembly **104** ready for placement of an inlet core device and FIG. **20A** shows the outlet cavity **134** ready for placement of an outlet core device.

[0097] FIGS. **19A-19E** represent sequential views showing the installation of an inlet core assembly **170** of FIGS. **8A-8C** linking the silicone strip assembly **104** with the green tire after the build and the curing of the green tire. The inlet core assembly **170** may be constructed of any suitable metal. In FIG. **19A**, a bottom half housing **180** may be inserted into the inlet cavity **132** after the inlet cavity has been enlarged by a cutting implement into a generally pointed shape (shown) or key shaped (not shown) as indicated by the scissor representation. The cutting implement may open the chafer strip groove, still occupied by silicone strip assembly **104**, to accommodate receipt of the conical half-protrusion **194** of the bottom half-housing **180**. The tapered end of the conical half-protrusion **194** may fit into the chafer channel occupied by the strip assembly **104**, as shown in FIG. **19B**, as the strip assembly is positioned within a half-channel **196** extending across the bottom half-housing **180** and conical half-protrusion. The extra length of inlet end portion **108** of the strip assembly **104** may be cut and removed thereby positioning a terminal end of the strip assembly **104** within the half-channel **196** of the bottom half-housing **180**.

[0098] An upper/outer top half-housing **178** may be attached to the bottom half-housing **180**, as seen in FIGS. **19C** & **19D**, thereby capturing the strip assembly **104** within the full channel formed by upper and lower half-channels **184**, **196**. Magnets **192** may secure the metallic half-housings **178**, **180** together. Rubber patches **228**, **230**, as seen in FIG. **19E**, may be applied over the inlet core assembly **170** to temporarily secure the assembly in place for curing of the green tire **12**. The patches **228**, **230** may be removed from the cured tire **12** so that the inlet core assembly **170** may operate in an unimpeded manner.

[0099] In accordance with the present invention, FIGS. **20A-20E** represent sequential views showing the installation of a metallic permanent outlet core assembly **136** of FIGS. **5A-7C** linking the silicone strip assembly **104** with the green tire after the build and the curing of the green tire. The metallic permanent outlet core assembly **136** may be constructed of

steel, stainless steel, titanium, aluminum, and/or other suitable metal. In FIG. 20A, a metallic outlet housing 144 may be inserted into the circular outlet cavity 134, and secured to, the end portion 106 of the silicone strip assembly 104. A screw punch 138, threadedly secured to the outlet housing 144, may be pushed through to protrude through an inner tire wall into the tire cavity 20 from the outlet cavity 134, as seen in FIG. 20B. FIG. 20B further shows the outlet housing 144 fully seated into the outlet cavity 134 with the tapered conical half-protrusion 159 projecting into the tire cavity 20. The strip assembly 104 has been inserted into a slot 152 in the outlet housing 144.

[0100] In FIGS. 20C & 20D, the screw punch 138 has been removed and replaced by a threaded valve 140 attached to a screw thread 146 of the outlet housing 144. In FIG. 20E, an uncured circular disk 160 of material similar to the uncured material of the chafer 70 may be fitted into the circular outlet cavity 134 thereby sealing the already inserted outlet housing 144. During curing, the disk 160 will permanently bond to the perimeter of the outlet cavity 134 and provide a pneumatic seal for preventing air travel from the tire cavity 20 through the outlet cavity to atmosphere 21.

[0101] FIGS. 3A, 3B, 4A, and 4B show the tire 12 with the inlet and outlet assemblies 136, 170 in place. The silicone core assembly 104 is enclosed/encased within the chafer component 28 of the green tire 12 and extends 180 degrees between the outlet core assembly 136 and the inlet core assembly 170. FIG. 3B shows an enlarged detail of the inlet core location and FIG. 4B shows an enlarged detail the outlet core location. The silicone core assembly 104 resides enclosed within a chafer channel 105 thereby preserving the structural integrity of the chafer channel throughout the curing of the tire 12. The sectional configuration of the silicone core assembly 104 may be complementary to chafer channel 105 and may be surrounded by chafer composition thereby maintaining the configuration of the chafer channel throughout tire cure (FIG. 16C).

[0102] As described above, the air maintenance assembly 42 may represent a peristaltic air pump system in which the compressible air passageway 238 progressively pumps air along the passageway from the inlet cavity 132 to the outlet cavity 134 and the tire cavity 20 for maintaining internal tire cavity pressure at a required level. The inlet assembly 170 and the metallic permanent outlet assembly 136 may be positioned generally 180 degrees apart, separated by the internal chafer air passageway 238 (FIG. 21). 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 238 adjacent the footprint. Flattening of the segment of the passageway 238 may force air from the segment along the internal passageway 238 in a direction toward the permanent outlet assembly 136.

[0103] As the tire 12 continues to rotate, the air passageway 238 within the chafer component 28 may be sequentially flattened/squeezed adjacent the tire footprint in a segment by segment direction opposite to the direction of tire rotation. The sequential flattening of the air passageway 238 segment by segment may thus cause evacuated air from the flattened segments to be pumped to the permanent outlet assembly 136. When the air flow pressure is sufficient against the permanent outlet assembly 136, 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.

[0104] With the tire 12 continuing to rotate, flattened tube segments may be sequentially refilled by air flowing into the inlet assembly 170 along the passageway 238. The inflow of air from the inlet assembly 170 may continue until the outlet assembly 136 becomes adjacent the tire footprint. When the tire 12 rotates further, the inlet assembly 170 will eventually pass the tire footprint against ground surface, and airflow may resume to the outlet assembly 136 along the passageway 238.

[0105] The above-described cycle may then be repeated for each tire revolution, half of each rotation resulting in pumped air going to the tire cavity 20 and half of the rotation resulting in pumped air being directed back out the inlet assembly 170. 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.

[0106] The location of the assembly 42 may be in the chafer component 28 with the air passageway 238 thereby being in a high flex region of the tire 12 causing the flattening pressure from the tire rolling against ground surface to be applied to the passageway. The air maintenance passageway 238 may be integrated into and enclosed by the chafer tire component 28 to prevent air leakage that would otherwise degrade the operational efficiency of the pump assembly 42. Other tire components may have high-flex regions and may alternatively be employed for location of the air maintenance assembly 42. For example, without intent to delimit such alternative components and locations, the assembly 42 may be incorporated at a more radially outward location in the tire sidewall 14. The passageway 238 could, in similar manner to that described previously, be deployed within a sidewall ply component during green tire build.

[0107] Pursuant to the foregoing, it will be appreciated that a method of constructing a tire 12 having an associate air maintenance pumping assembly 42 results in the tire. The method may include: constructing an elongate strip core 58; encasing the strip core 58 into a containment within an uncured flexible tire component (preferably but not necessarily chafer strip 70), the strip core extending between an air inlet cavity 132 and an air outlet cavity 134 in the flexible tire component; building on a tire building drum 116 a green tire carcass from tire components including the flexible tire component and encased strip core 58; inserting an air inlet assembly 170 into the inlet cavity 132 and an air outlet assembly 136 into the outlet cavity 134; curing the green tire carcass into a cured finished tire 12 including the flexible tire component 70 containing the strip core 58; and removing the encased strip core 58 from the cured flexible tire component to leave within the flexible tire component an unobstructed air passageway 238 interconnecting the assemblies 136, 170.

[0108] It may be further appreciated that the strip core 58 may be longitudinally removed by a free end from the cured flexible tire component, chafer strip 70, generally tangential to the tire carcass, by means of drawing on the free end 108 of the strip core and extending the outlet assembly 136 inward through a tire sidewall 14 by means of utilization of the punch 138 into communication with the tire cavity 20. The method may further include inserting an air inlet assembly 170 into the inlet cavity 132 prior to curing the green tire carcass; and

inserting an air outlet assembly 136 into the outlet cavity 134 prior to curing the green tire carcass. The assemblies 136, 170 at the inlet and outlet positions may serve to further seat the assemblies within the tire 12 during the tire cure.

[0109] The method may also include encasing the strip core 104 into a containment within the uncured flexible tire component by extruding a channel or tube into the uncured flexible tire component (chafer strip 70) defined by channel sidewalls 82, 84 and a channel bottom wall 86; inserting the strip core 104 into the channel; and collapsing a flexible channel sidewall or flap 114 to enclose the sidewall 82 over the strip core 104. The uncured flexible tire component may be a tire chafer component, but other alternative tire components may be substituted so long as the tire components exhibit sufficiently high flexure during tire rotation under load to progressively collapse the air passageway 238 in a rolling tire footprint.

[0110] It may further be appreciated that the assemblies 136, 170 at the inlet and outlet cavities 132, 134 may provide a connector system that is flexible and multi-purpose. In the air maintenance tire and connector system 42 thus provided, the elongate integral air passageway 238 may be formed by the silicone strip assembly 104 at the pre-cure tire build stage and by the vacated air passageway post-cure removal of the assembly 104 in a post-cure procedure.

[0111] The chafer component strip 70, as may be appreciated from FIGS. 12-17, may represent a flexible tire component strip forming a portion of the tire 12. The tire component strip in the form of the chafer strip 70 may provide: the channel 90 within an upper surface defined by opposed strip lip portions 82, 84 and a channel bottom wall 86; and the air passageway 238 formed within the flexible chafer tire component 70 extending between the inlet cavity 132 and the outlet cavity 134 in at least a partial circumferential (e.g., 180 degree) path around the tire 12. The elongate passageway-shaping strip assembly 104 may occupy and form the air passageway 238 of the flexible chafer tire component 70 during green tire build and tire cure. The passageway-shaping, silicone strip assembly 104 may be operative to form and maintain the air passageway 238 to a desired cross-sectional configuration which may duplicate the cross-sectional configuration of the silicone strip assembly 104.

[0112] The passageway-shaping, silicone strip assembly 104 may be removable from the air passageway 238 in a post-cure procedure. The free end portions 106, 108 may be accessible at the inlet and outlet cavities 132, 134, respectively, and inlet and outlet assemblies 170, 136, respectively, whereby the silicone strip assembly 104 may be removed by an axial withdrawal force application to one of the free end portions 106, 108 of the silicone strip assembly 104.

[0113] In FIGS. 11 and 16A-16C, the passageway-shaping strip assembly 104 may have a generally elliptical cross-sectional configuration and may be configured with a silicone core 58 encased by a sheath 92 composed of a release material such as a rubber composition. The flexible chafer tire component 70 may increase side-to-side (the axial direction of the tire 12) in sectional thickness from the radially outward region 72 to the radially inward region 88. The channel 90, which may become the air passageway 238, may reside within the radially inward, thicker region 88. The channel 90 may be formed to extend into the radially inward region 88, angling radially inward toward the radially outward region 72, as shown in FIGS. 16A-16C at an angle θ within an exemplary range between -20 to $+20$ degrees.

[0114] With reference to FIG. 21, a method of extracting the elongate strip assembly 104 from the air passageway 238 defined by the assembly may occur in a post-cure procedure. The assembly 104 may be extracted longitudinally from occupancy within the flexible tire component (chafer 28), thereby defining the air passageway 238 within the chafer component by the space previously occupied by the elongate strip assembly 104. The elongate strip free end portion 108 may be accessible at the inlet cavity 132 and inlet assembly 170 and the free end portion 106 at the outlet cavity 134 and outlet assembly 136. The elongate strip assembly 104 may be moved and extracted tangentially end to end relative to the tire 12 from the inlet cavity 132 by a withdrawal force applied to the elongate strip free end 108. Alternatively, the assembly 104 may be extracted from the outlet opening 134 by means of the free end 106. Application of the withdrawal force may be in the form of a tensile force applied to the free end portion 108 of the elongate strip assembly 104 alone or in conjunction with other extraction techniques. For example and without restriction, an extraction pneumatic system (not shown) may be deployed to push the assembly 104 from the air passageway 238. The pneumatic system may include an air blow gun on to which a nozzle is attached.

[0115] 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 connector system and 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 metallic connector assembly within the outlet cavity, the connector assembly including a through-channel for conducting air flow communication between the air passageway within the flexible tire component and a chamber of the connector assembly.
2. The connector system and tire assembly of claim 1 wherein the flexible tire component comprises a chafer component of the tire.
3. The connector system and tire assembly of claim 1 wherein the connector assembly includes a valve device for regulating a flow of air from the air inlet cavity to the tire cavity.
4. The connector system and tire assembly of claim 1 further comprising an elongate core strip positioned within the air passageway of the tire flexible component, the through-channel of the connector assembly having a cross-sectional configuration to receive a free end of the core strip therethrough.
5. The connector system and tire assembly of claim 1 wherein the through-channel comprises a through-slit.

6. The connector system and tire assembly of claim 1 wherein an inlet connector assembly within the air inlet cavity includes an air inlet device for conducting air external to the tire into the air inlet cavity and a metallic outlet connector assembly within the air outlet cavity includes a valve device for regulating a flow of air from the air outlet cavity to the tire cavity.

7. The connector system and tire assembly of claim 1 wherein the flexible tire component comprises a chafer component of the tire.

8. The connector system and tire assembly of claim 1 further comprising a removable elongate core strip positioned within the air passageway of the flexible tire component during a pre-cure build of the tire and withdrawn from the air passageway of a post-cure tire, a through-channel of both the inlet connector assembly and the outlet connector assembly each having a cross-sectional configuration to receive a respective free end of the core strip therethrough.

9. The connector system and tire assembly of claim 8 wherein each through-channel comprises a through-slit.

10. The connector system and tire assembly of claim 1 wherein the metallic connector assembly is constructed of steel.

11. The connector system and tire assembly of claim 1 wherein the metallic connector assembly is constructed of titanium.

12. The connector system and tire assembly of claim 1 wherein the metallic connector assembly is constructed of aluminum.

13. The connector system and tire assembly of claim 1 wherein the metallic connector assembly is constructed of stainless steel.

14. The connector system and tire assembly of claim 1 wherein the metallic connector assembly is constructed of stainless steel and titanium.

15. The connector system and tire assembly of claim 1 wherein the metallic connector assembly is constructed of stainless steel and aluminum.

16. The connector system and tire assembly of claim 1 wherein the metallic connector assembly is constructed of titanium and aluminum.

17. The connector system and tire assembly of claim 1 wherein the metallic connector assembly is constructed of stainless steel, aluminum, and titanium.

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