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Hinque

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(54) **COMPACT VALVE SYSTEM FOR SELF-INFLATING TIRE**

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

(72) Inventor: **Daniel Paul Luc Marie Hinque**, Habay-la-Neuve (BE)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 421 days.

This patent is subject to a terminal disclaimer.

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B60C 23/12 (2006.01)

(52) **U.S. Cl.**
CPC ***B60C 23/12*** (2013.01); *Y10T 152/10495* (2015.01)

(58) **Field of Classification Search**
CPC B60C 23/10; B60C 23/12; B60C 23/004
USPC 152/419, 423–426
See application file for complete search history.

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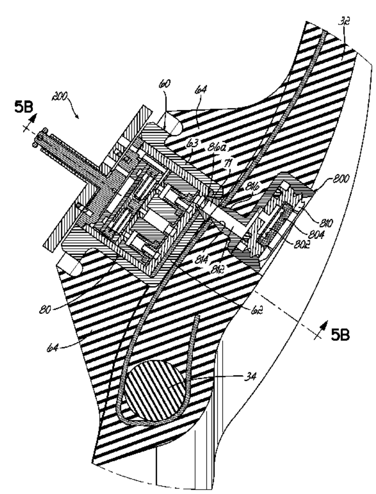
Primary Examiner — Jason Bellinger
(74) *Attorney, Agent, or Firm* — June E. Rickey

(57) **ABSTRACT**

A tire having a tire cavity is disclosed, wherein the tire has a bi-directional pump assembly including a pump passageway having an inlet end and an outlet end, and being operative to allow a portion of the pump passageway near a tire footprint to substantially close and open the pump passageway. The tire includes a valve assembly having a valve housing, wherein a diaphragm is mounted in the valve housing forming an interior chamber, and wherein the diaphragm is responsive to the pressure of the tire cavity. The interior chamber has a first hole in fluid communication with the inlet end of the pump passageway, a second hole in fluid communication with the outlet end of the pump passageway, and a third hole in fluid communication with the outside air. The valve housing has a passageway in fluid communication with the tire cavity and the outlet end of the pump. The valve assembly further includes an inlet control valve having a valve bottom positioned over the third hole and operative to open and close the third hole to allow air to enter the system. The inlet control valve has a first end connected to the diaphragm, and a resilient member biases the inlet control valve into the open position.

27 Claims, 20 Drawing Sheets



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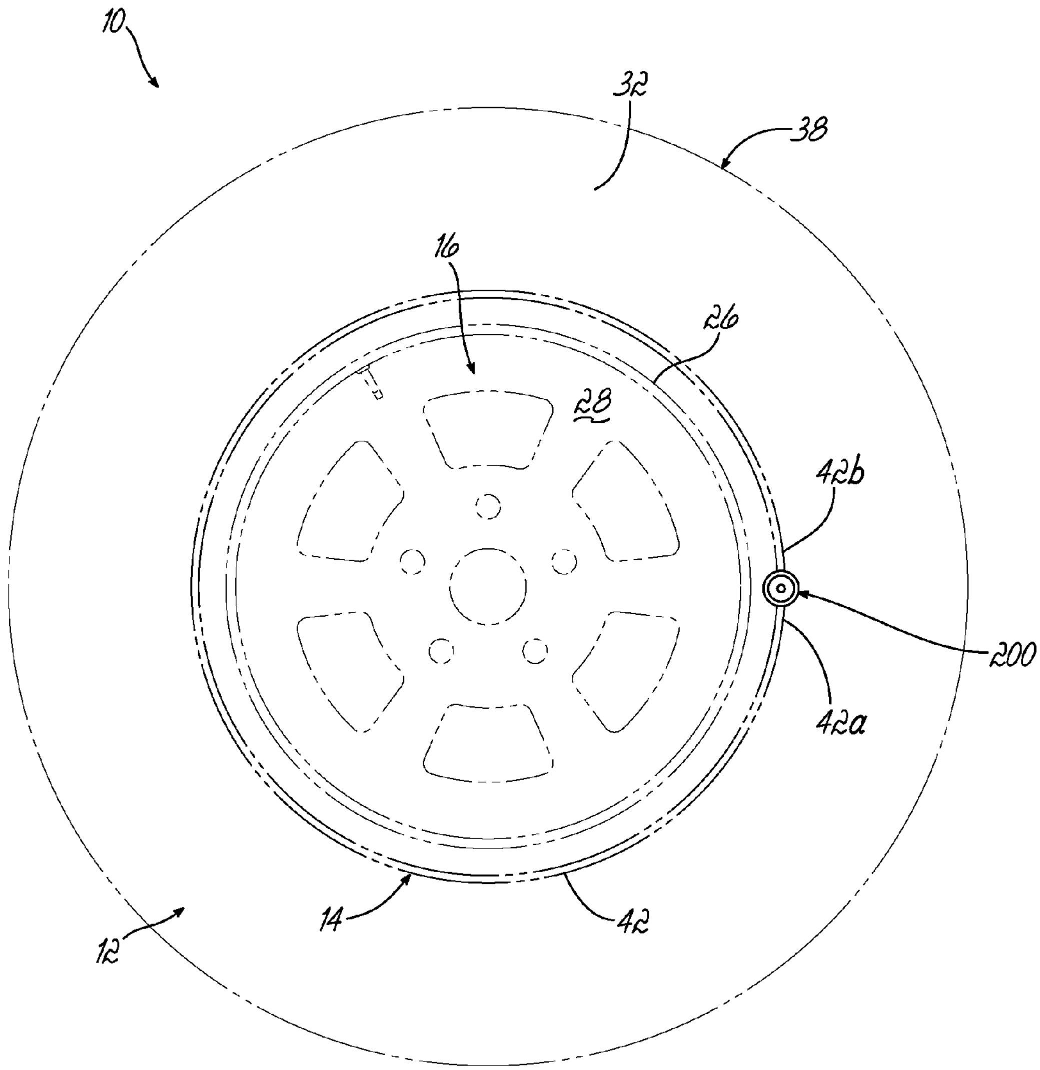
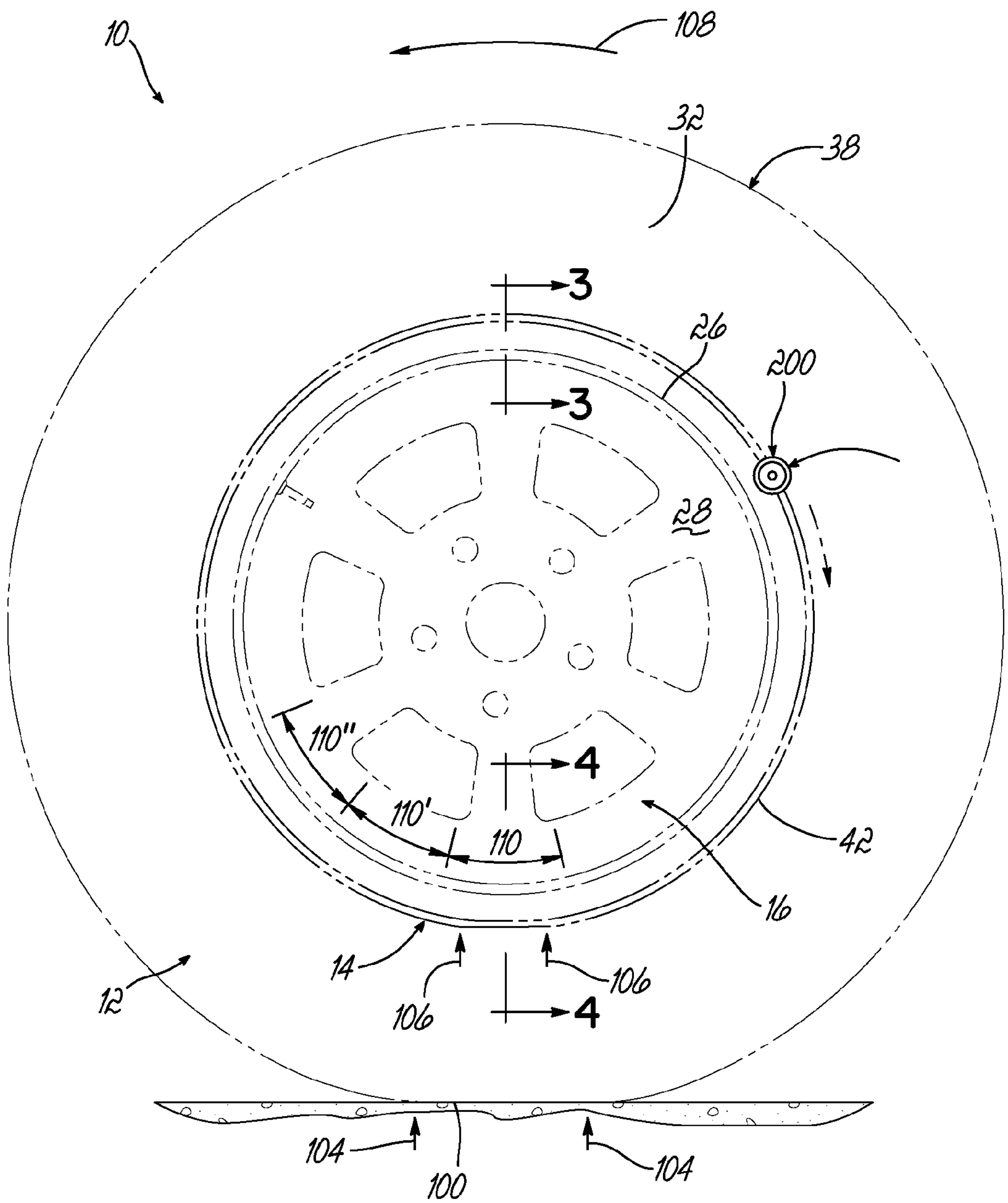


FIG. 1


10
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32
38
3
3
26
200
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110''
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4
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42
16
14
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100
104

FIG. 2

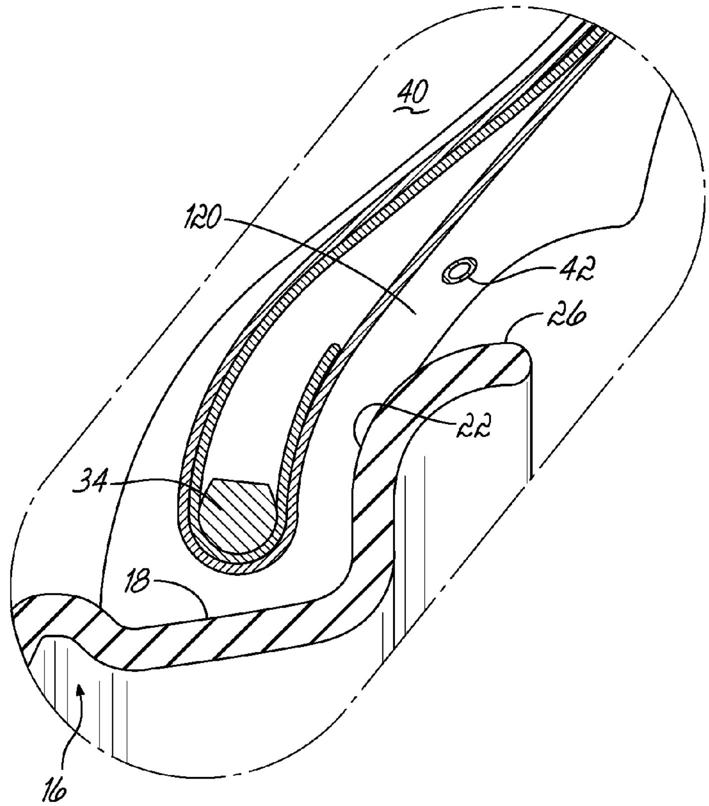

FIG. 3

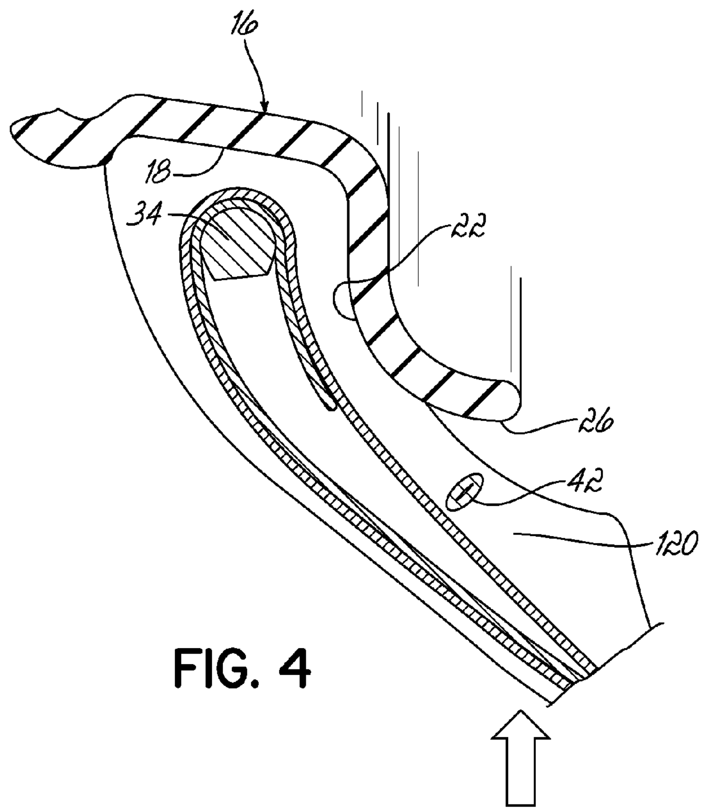

FIG. 4

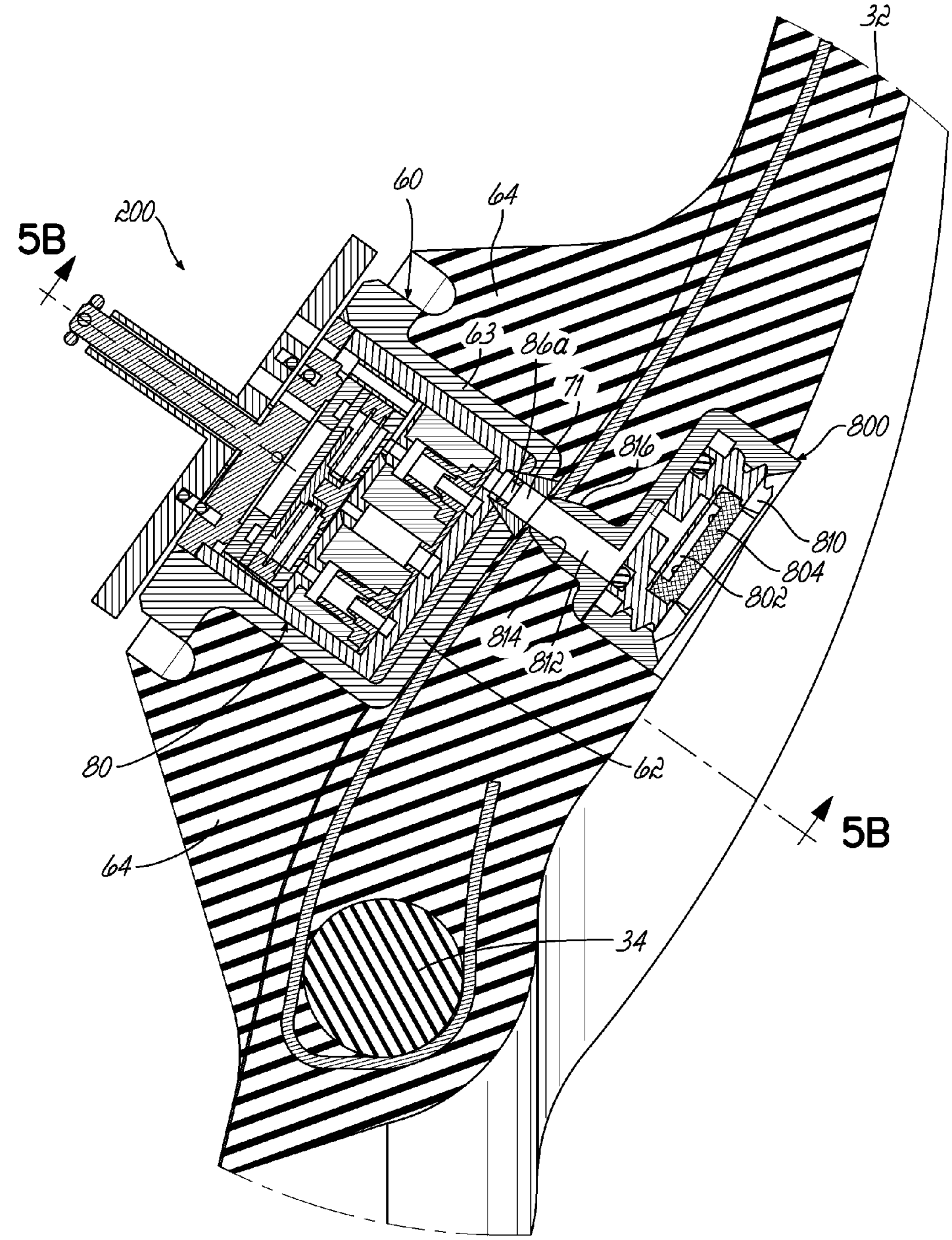

FIG. 5A

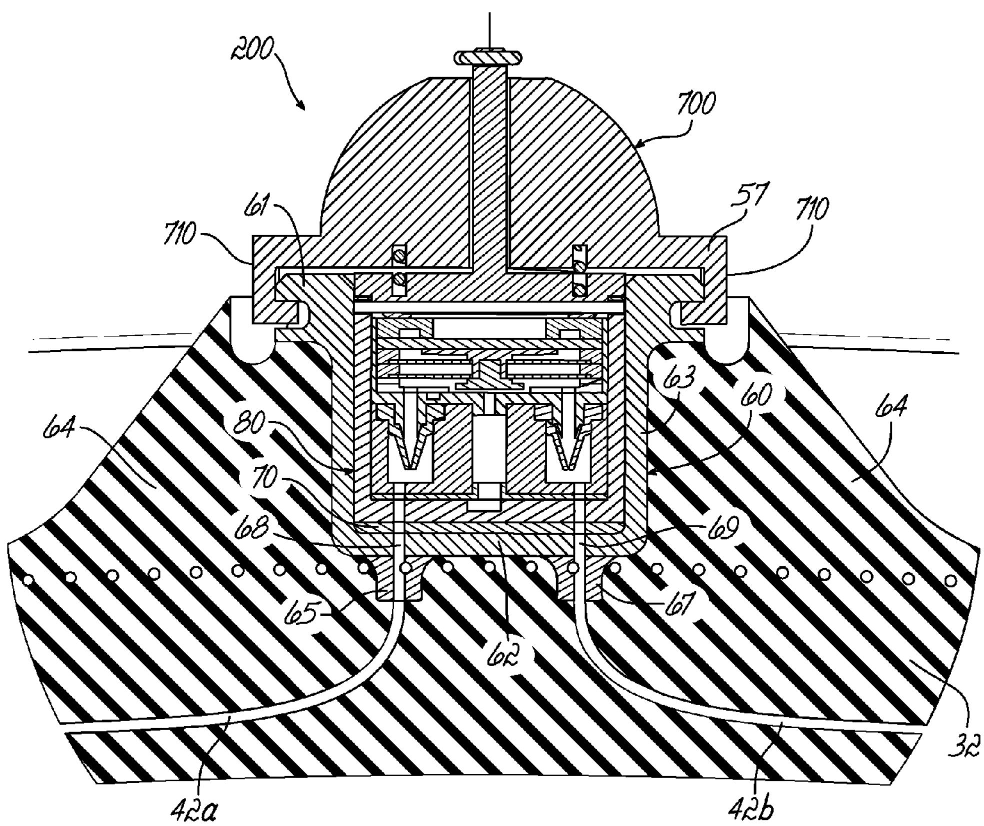

FIG. 5B

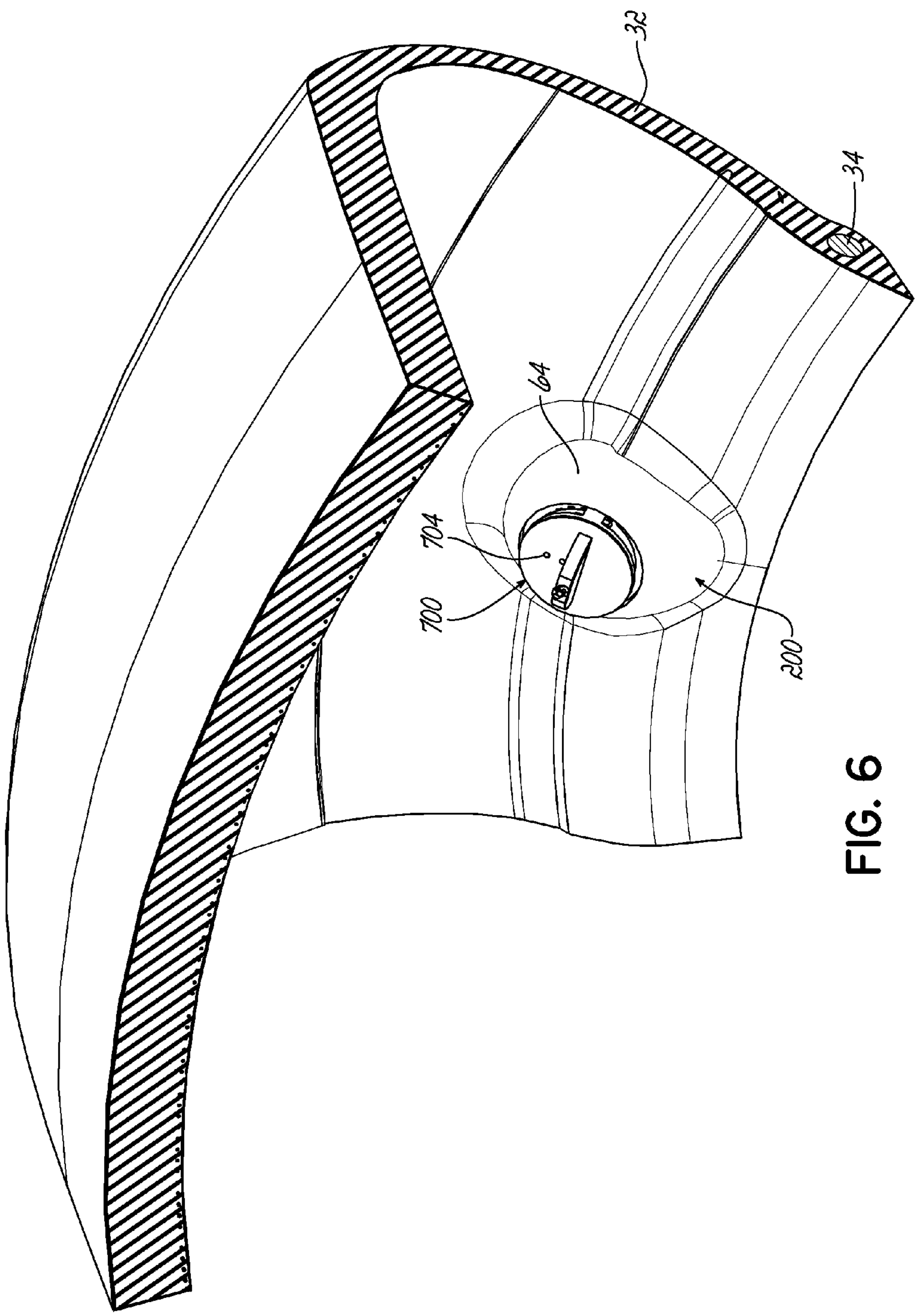

FIG. 6

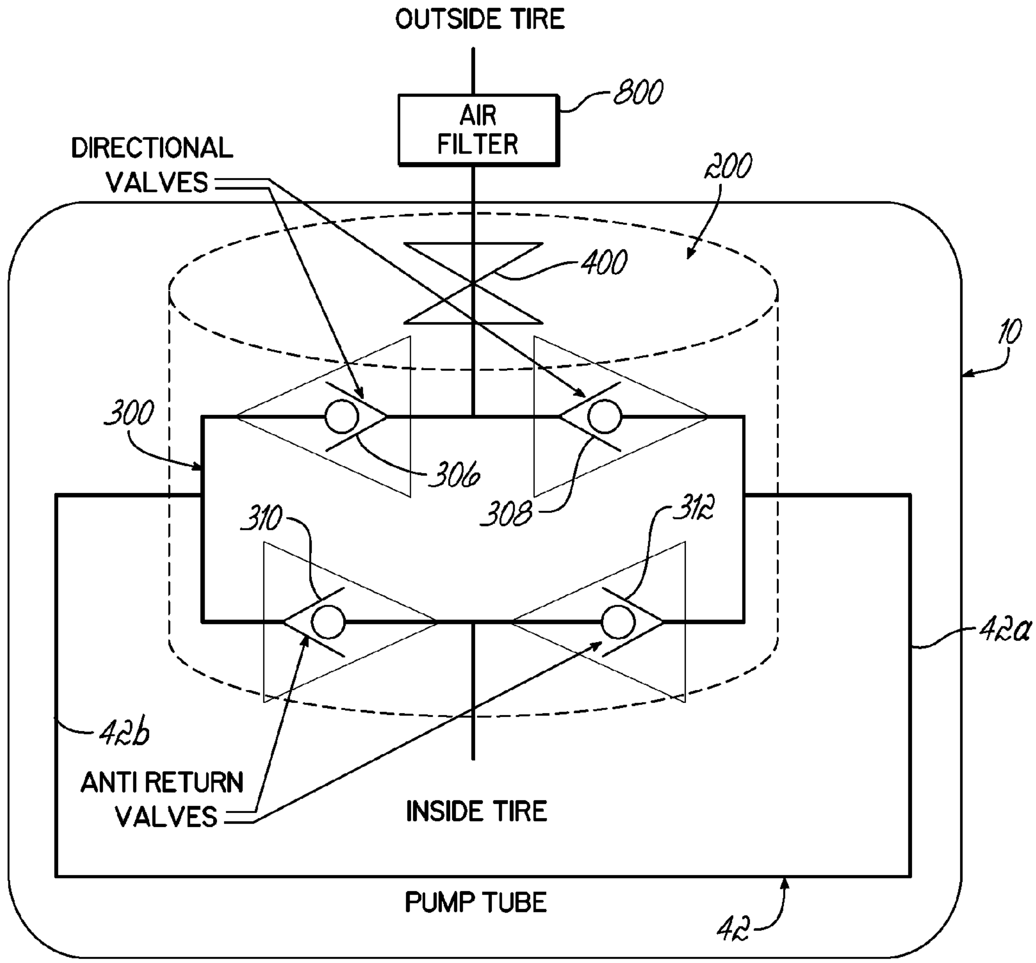
OUTSIDE TIRE
AIR FILTER
800
DIRECTIONAL VALVES
200
400
10
300
306
308
310
312
42a
42b
ANTI RETURN VALVES
INSIDE TIRE
PUMP TUBE
42

FIG. 7

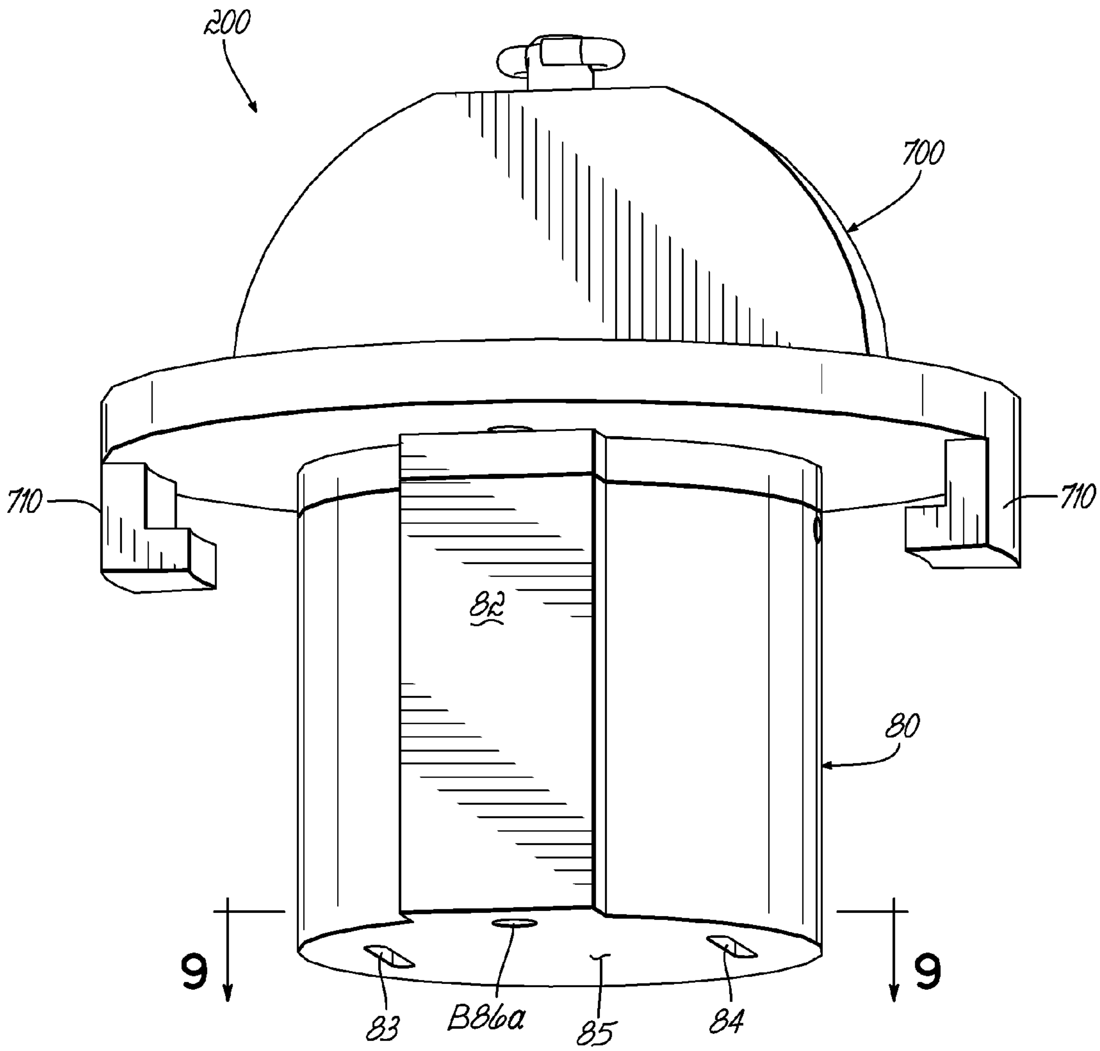

FIG. 8

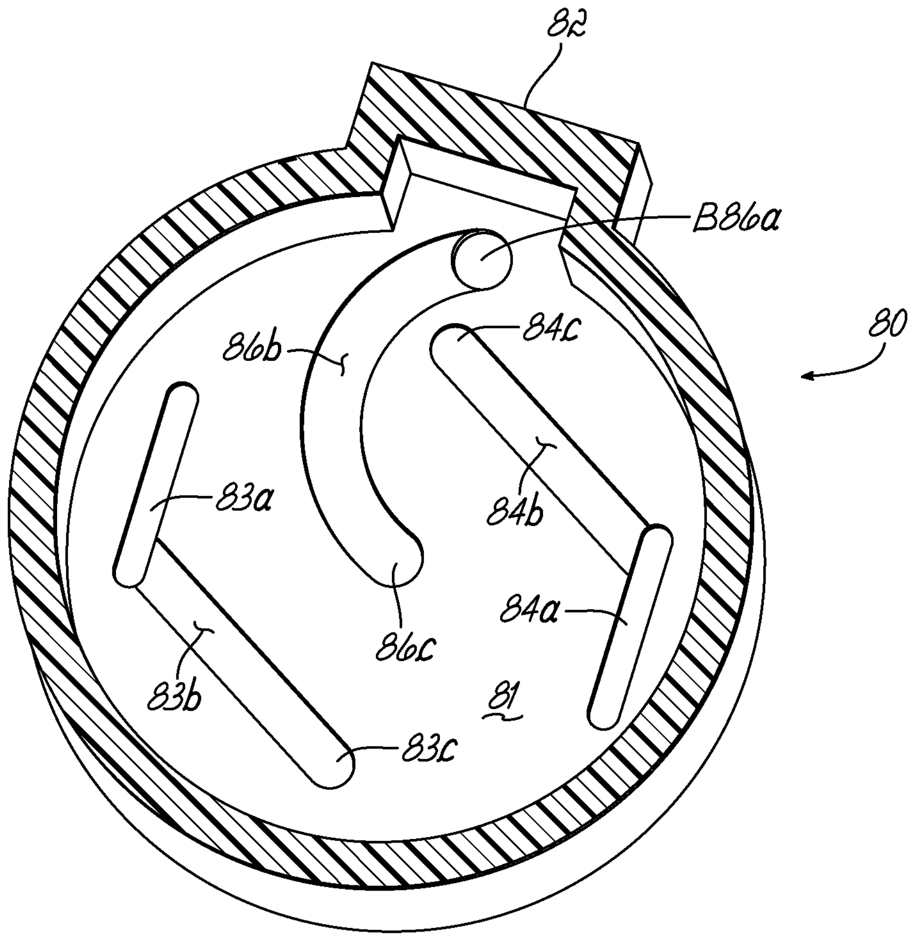

FIG. 9

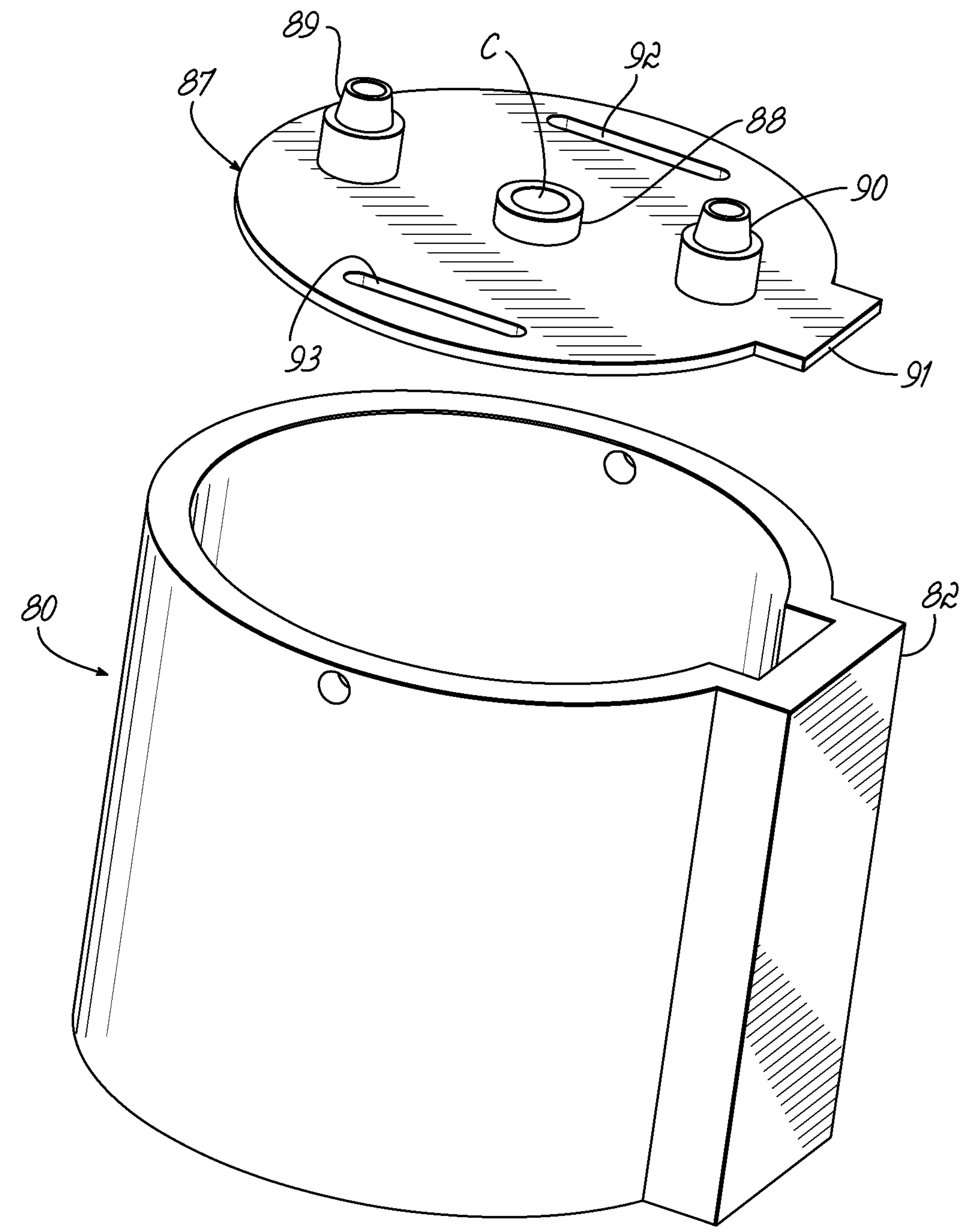

FIG. 10

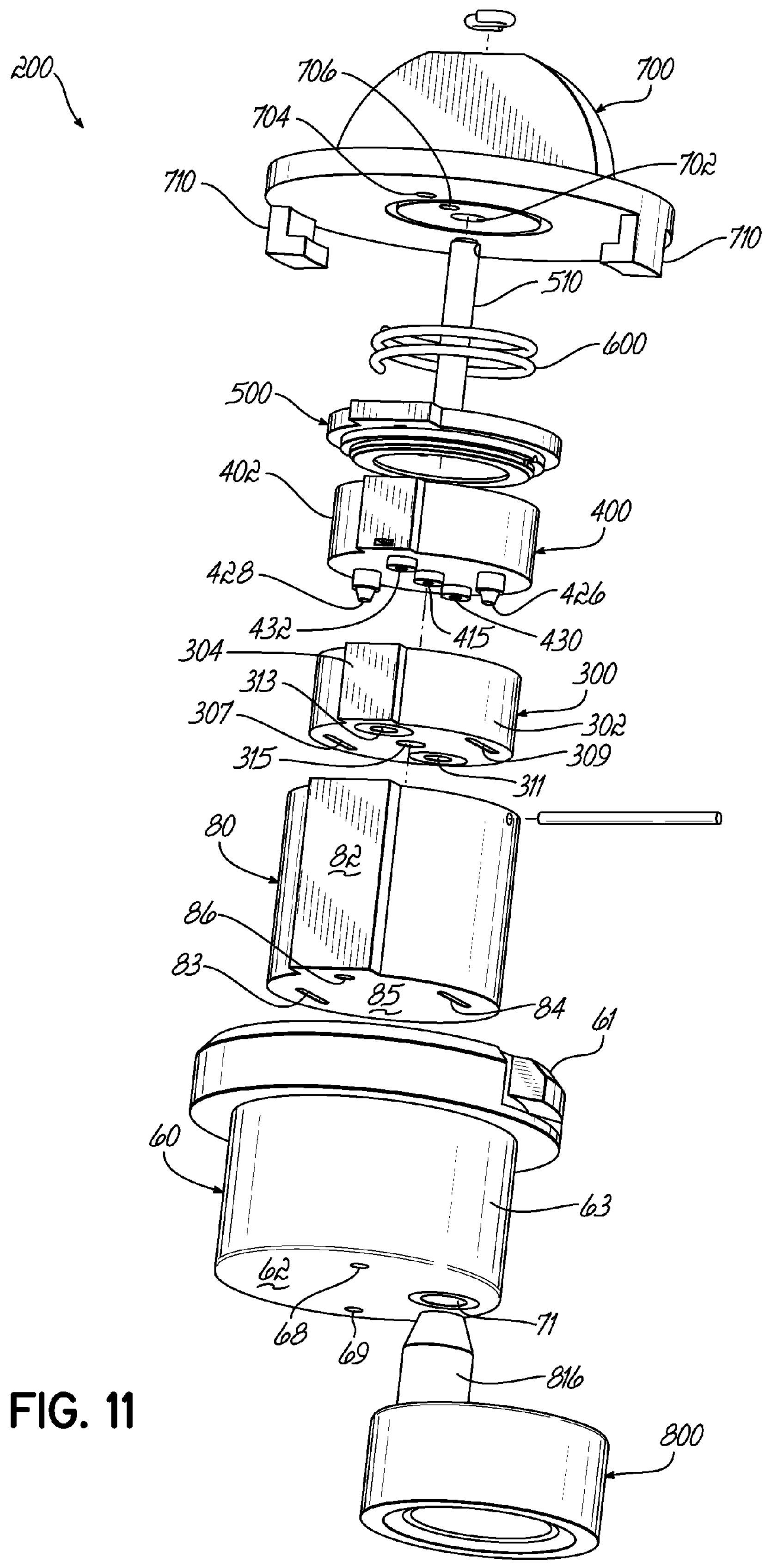
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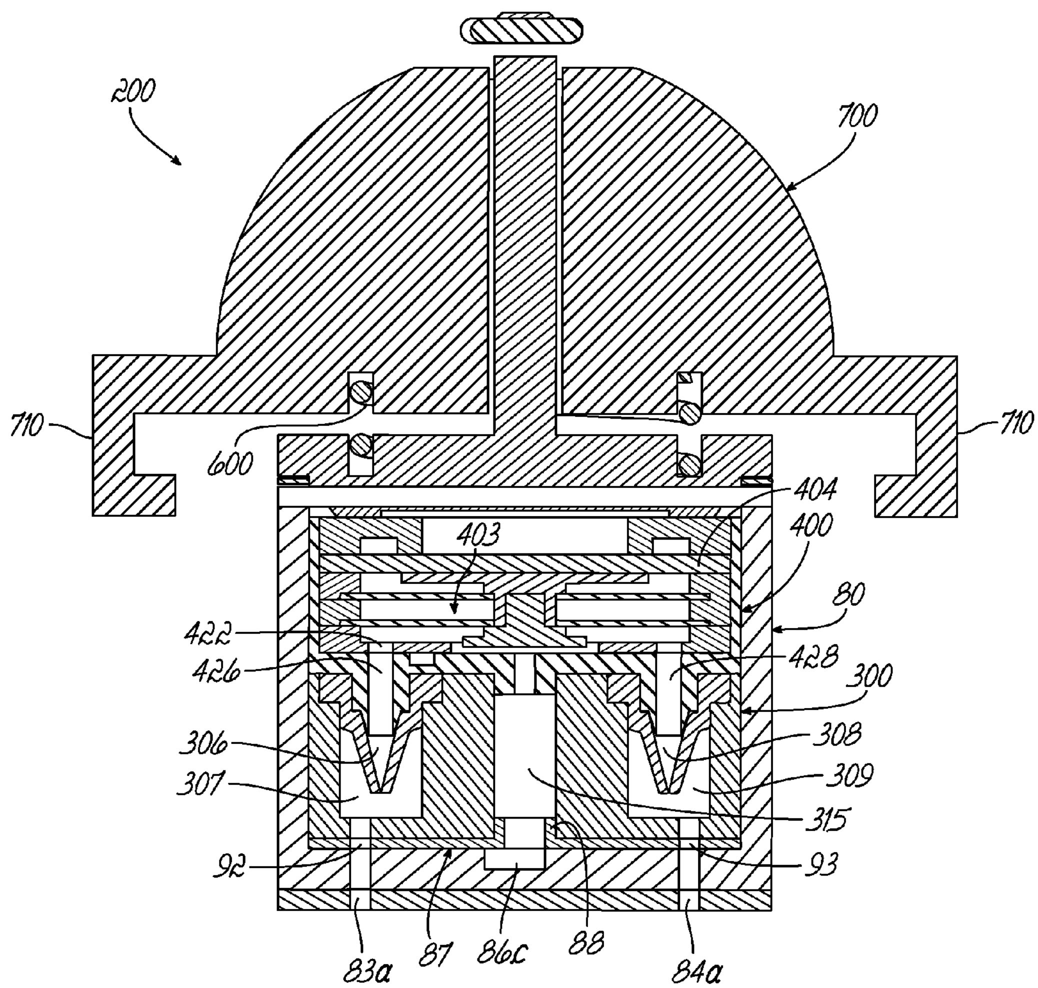
FIG. 11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83a
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FIG. 12

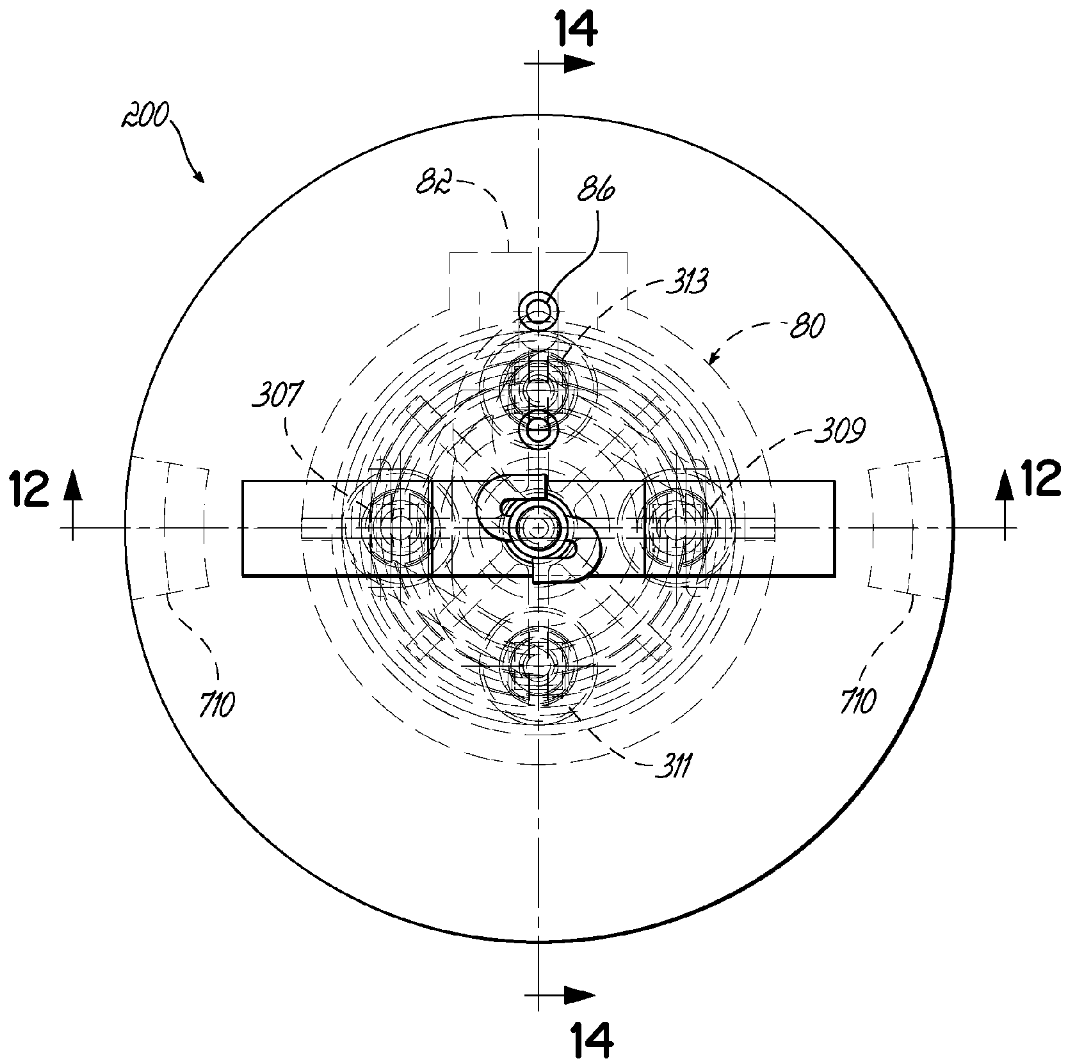

FIG. 13

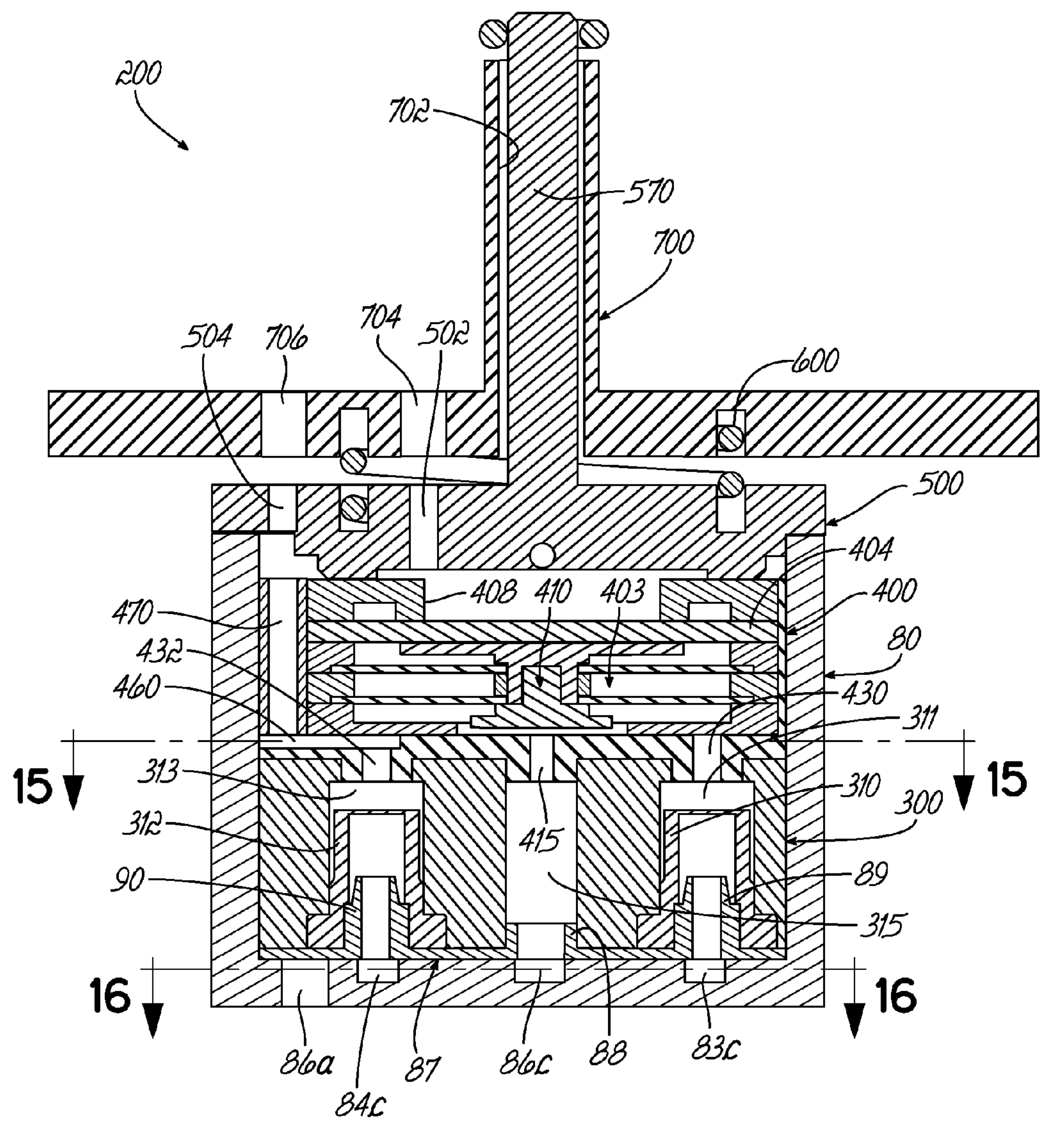
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FIG. 14

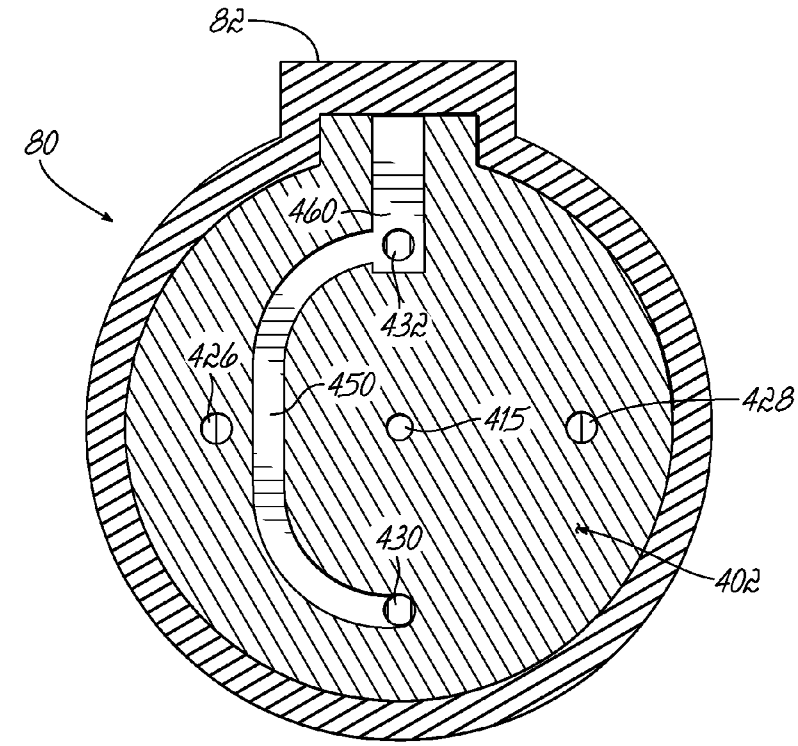
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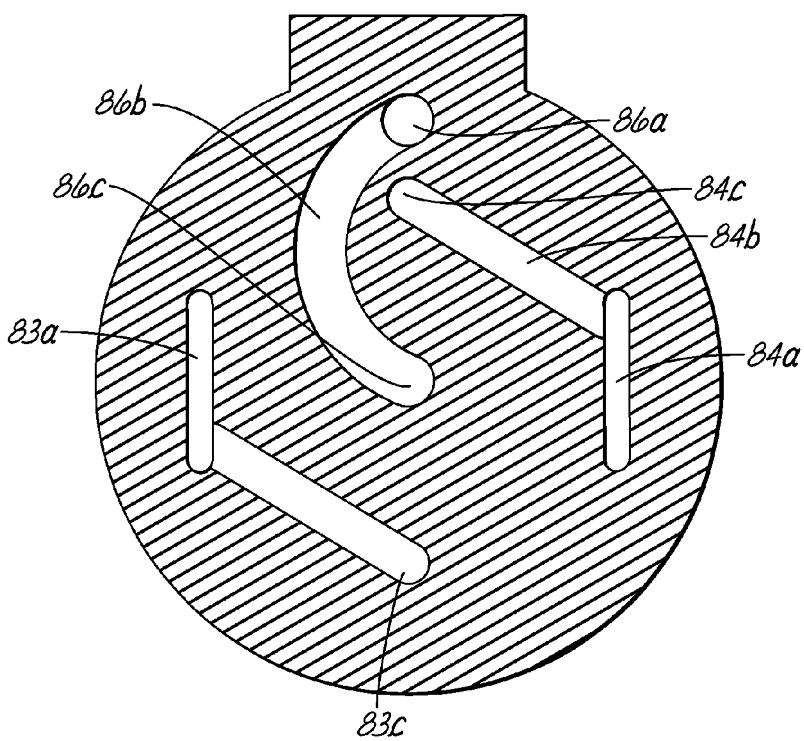
FIG. 15


86b
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84a
83c

FIG. 16

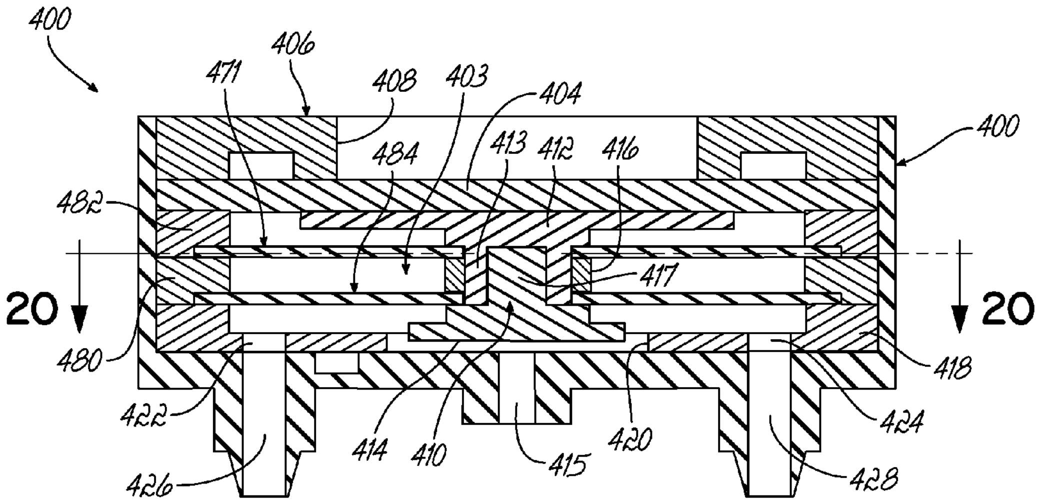

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FIG. 17

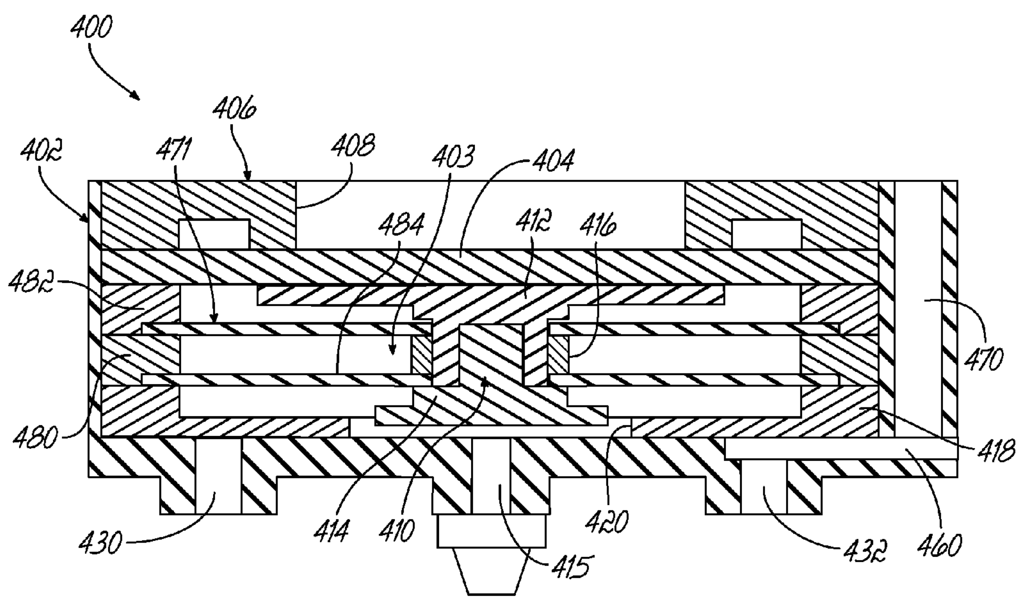

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FIG. 18

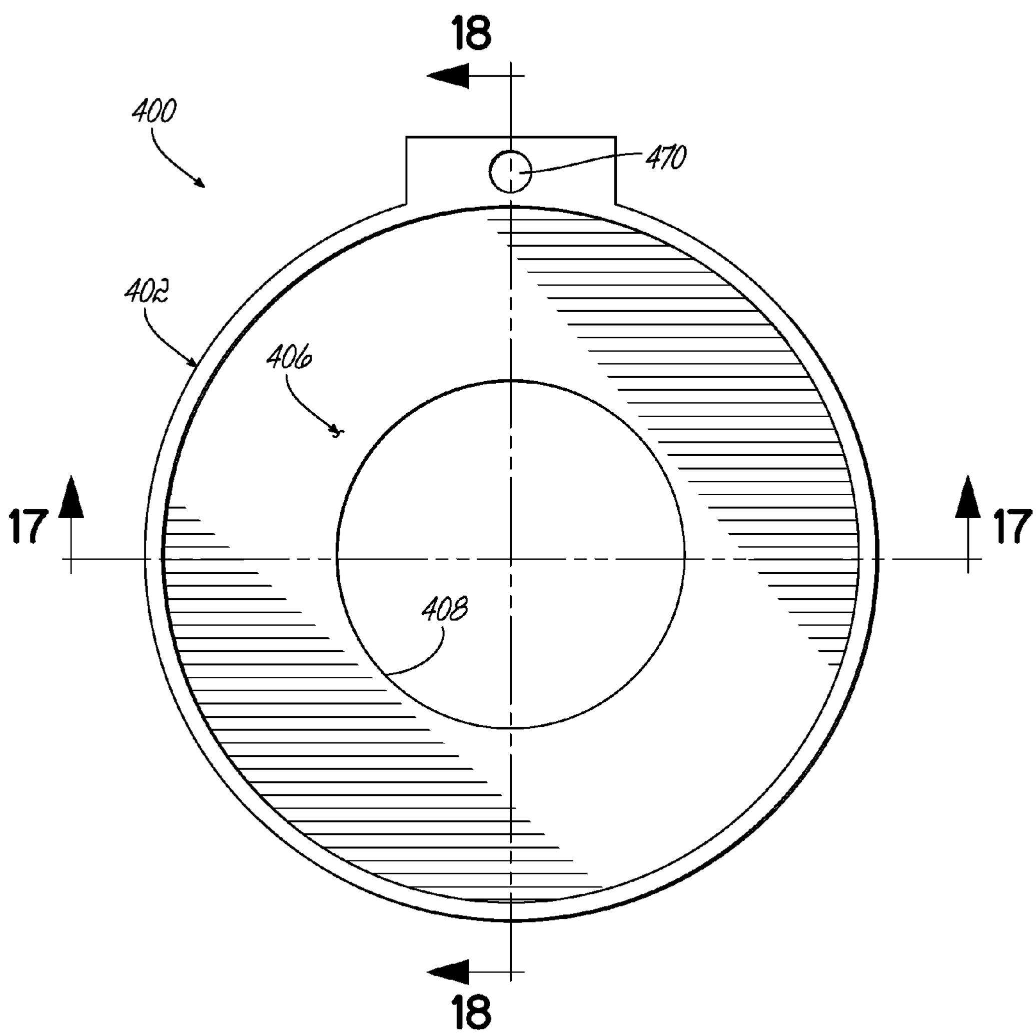

FIG. 19

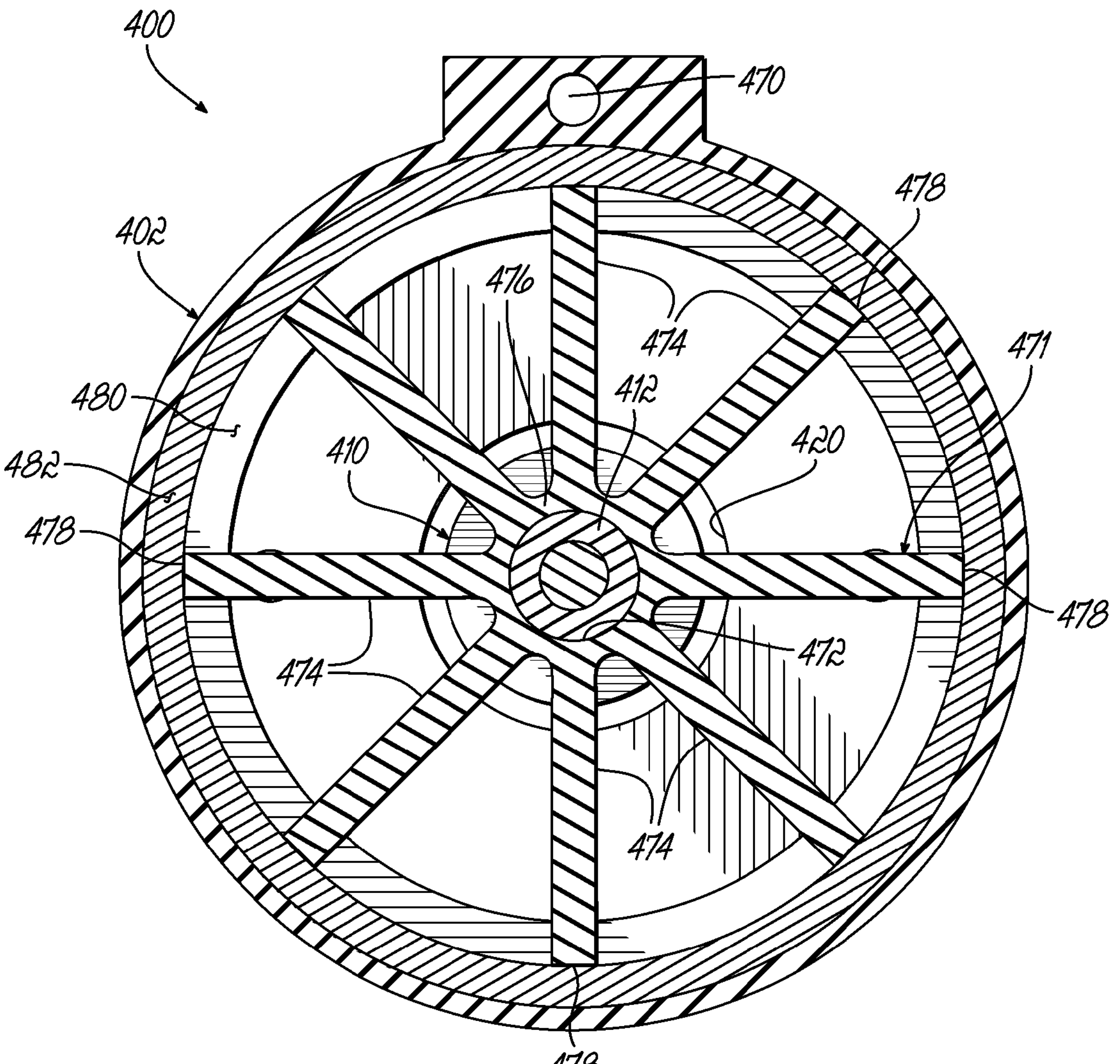

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FIG. 20

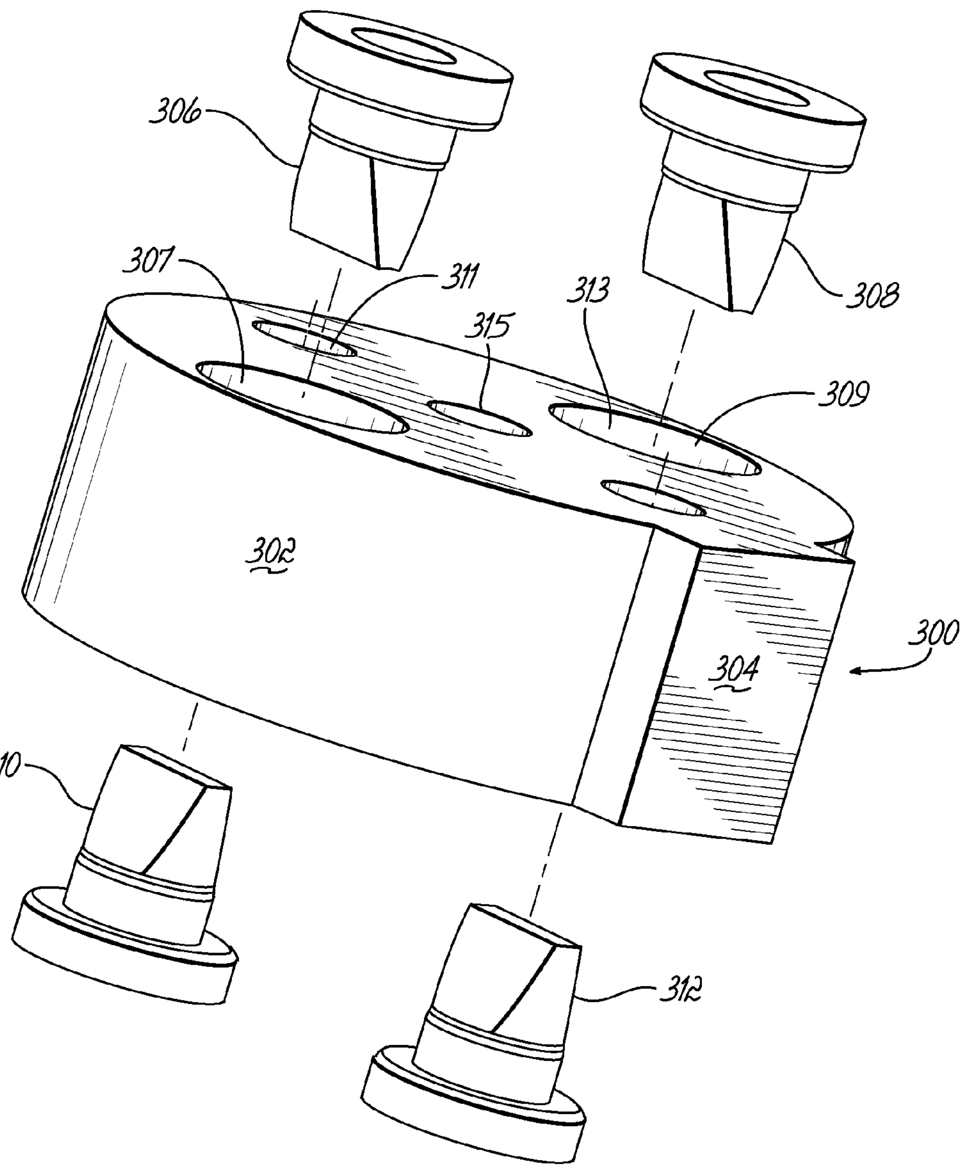

FIG. 21

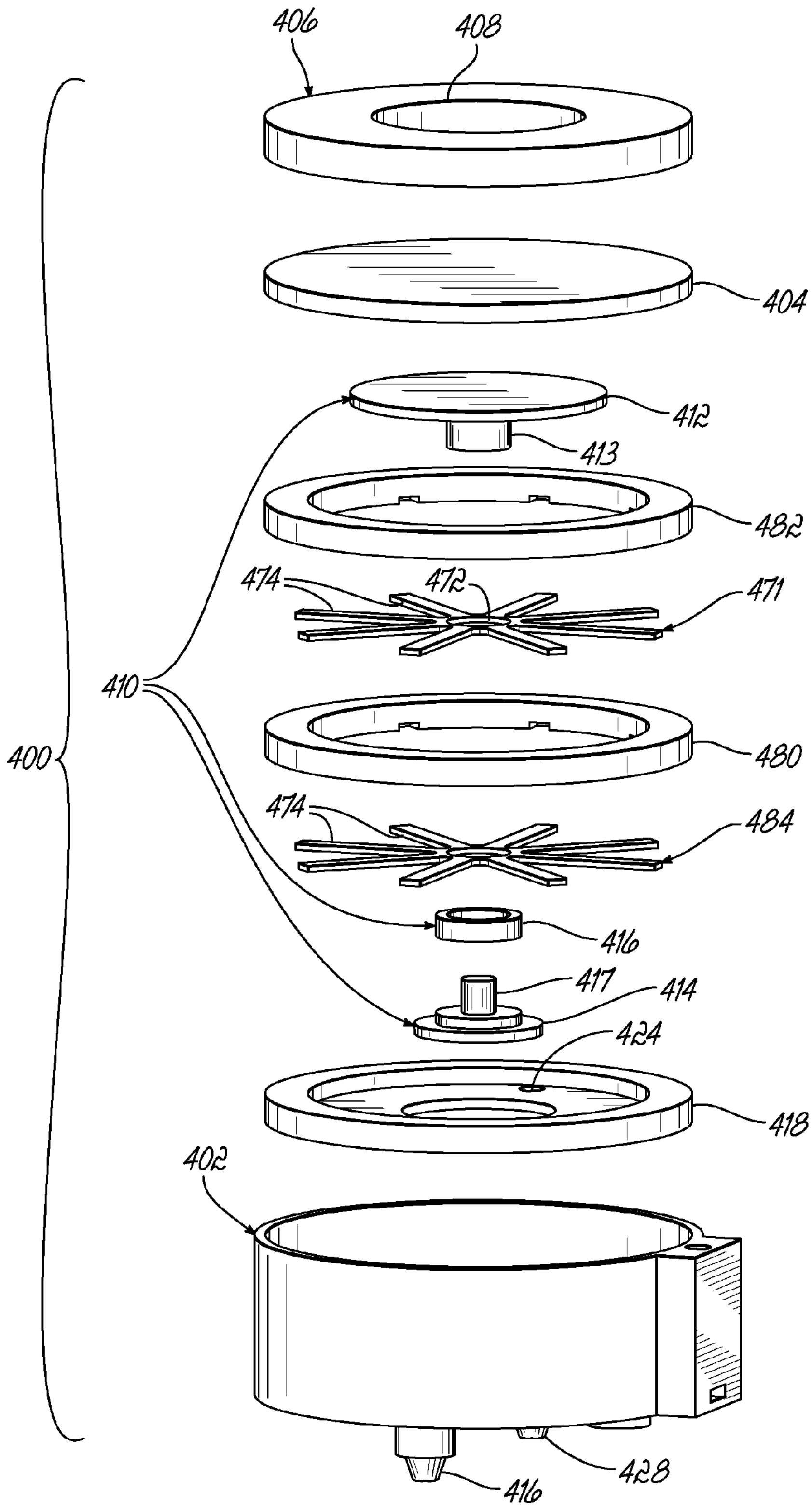
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FIG. 22

COMPACT VALVE SYSTEM FOR SELF-INFLATING TIRE

FIELD OF THE INVENTION

The invention relates generally to self-inflating tires and, more specifically, to a pump mechanism for such tires.

BACKGROUND OF THE INVENTION

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 a self-inflating feature within a tire that will self-inflate the tire in order to compensate for any reduction in tire pressure over time without the need for driver intervention.

SUMMARY OF THE INVENTION

The invention provides in a first aspect a tire having a tire cavity, wherein the tire has a bi-directional pump assembly including a pump passageway having an inlet end and an outlet end, and being operative to allow a portion of the pump passageway near a tire footprint to substantially close and open the pump passageway. The tire includes a valve assembly having a valve housing, wherein a diaphragm is mounted in the valve housing forming an interior chamber, and wherein the diaphragm is responsive to the pressure of the tire cavity. The interior chamber has a first hole in fluid communication with the inlet end of the pump passageway, a second hole in fluid communication with the outlet end of the pump passageway, and a third hole in fluid communication with the outside air. The valve housing has a passageway in fluid communication with the tire cavity and the outlet end of the pump. The valve assembly further includes an inlet control valve having a valve bottom positioned over the third hole and operative to open and close the third hole. The inlet control valve has a first end connected to the diaphragm, and a resilient member biases the inlet control valve into the open position.

The invention provides is a second aspect a tire having a bidirectional pump and valve assembly. The tire has a tire cavity, and a first and second sidewall extending respectively from first and second tire bead regions to a tire tread region; said tire having a pump passageway, said pump passageway having a first end and a second end and being operative to allow a portion of the pump passageway near a tire footprint to close and open the pump passageway when the tire is rotated in a first direction or second direction opposite said first direction, the valve assembly having a valve housing, wherein a diaphragm is mounted in the valve housing forming an interior chamber, and wherein the diaphragm is responsive to the pressure of the tire cavity; said interior chamber having a first hole A in fluid communication with a chamber A, a second hole B in fluid communication with the outside air; and a third hole C in fluid communication with a chamber C; said valve assembly further including an inlet control valve positioned in the interior chamber, wherein the inlet control valve is positioned over the second hole and operative to open and close the second hole to allow outside air to enter; wherein a resilient member is positioned in the interior chamber of the valve housing, and being connected to the inlet control valve, wherein the resilient member biases the inlet control valve into the open position; Wherein said chamber A has a one way valve positioned therein, and said chamber A is in fluid communication with the pump passageway first end and the interior chamber, Wherein said chamber C has a one way valve positioned therein, and said chamber C is in fluid communication with the pump passageway second end and the interior chamber; Wherein the valve housing has a chamber D, wherein said chamber D is in fluid communication with the tire cavity and a pump passageway first end, and said chamber D has a one way valve positioned therein; Wherein the valve housing has a chamber E, wherein said chamber E is in fluid communication with the pump passageway first end and the tire cavity, wherein a one way valve is positioned in chamber E.

DEFINITIONS

"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.

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

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

"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.

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

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

"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.

"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.

"Lateral" means an axial direction.

"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.

"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.

"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.

"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.

"Passageway" means an integrally formed pathway in the tire or a discrete tube inserted in the tire forming the pump.

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

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

"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.

"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.

"Tread element" or "traction element" means a rib or a block element defined by having shape adjacent grooves.

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

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. **1** is a front view of a tire and wheel assembly showing a pump and valve assembly.

FIG. **2** illustrates the tire and wheel assembly of FIG. **1** in operation during tire rotation.

FIG. **3** is an enlarged cross-sectional view of the bead area of the tire, including the pump.

FIG. **4** is an enlarged cross-sectional view illustrating the pump being compressed in the tire bead area.

FIG. **5**A is a cross sectional view of the bead area shown with the compact valve system and filter assembly of the present invention.

FIG. **5**B is an enlarged view of the compact valve system of FIG. **5**A, in a direction **5***b*-**5***b;*

FIG. **6** is a side perspective view of the compact valve system as viewed from inside the tire.

FIG. **7** is a schematic of the compact valve system of the present invention.

FIG. **8** is a side perspective view of the compact valve system, shown with the insert removed.

FIG. **9** is a top view of the retainer.

FIG. **10** is an exploded view of the retainer with the flow control plate.

FIG. **11** is an exploded view of the compact valve system and filter assembly.

FIG. **12** is a cross-sectional side view of the compact valve system, without the insert, in the direction **12-12** of FIG. **13**.

FIG. **13** is a top view of the compact valve system, without the insert.

FIG. **14** is a cross-sectional side view of FIG. **13** in the direction **14-14**.

FIG. **15** is a cross-sectional side view of FIG. **14** in the direction **15-15**.

FIG. **16** is a cross-sectional side view of FIG. **14** in the direction **16-16**.

FIG. **17** is a cross-sectional view of the inlet control valve in the direction **17-17** of FIG. **19**.

FIG. **18** is a cross sectional view of the inlet control valve in the direction **18-18** of FIG. **19**.

FIG. **19** is a top view of the inlet control valve.

FIG. **20** is a section view of the inlet control valve of FIG. **17** in the direction **20-20**.

FIG. **21** is an exploded view of the flow controller.

FIG. **22** is an exploded view of the inlet control valve.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. **1** and **3**, a tire assembly **10** includes a tire **12**, a peristaltic pump assembly **14**, and a wheel **16**. The tire mounts in a conventional fashion to a rim having rim mounting surfaces **18** located adjacent outer rim flanges **22**. The outer rim flange **22** has an outer rim surface **26**. An annular wheel body **28** joins the rim flanges **22** and supports the tire assembly as shown. The tire is of conventional construction, having a pair of sidewalls **32** extending from opposite bead areas **34** to a crown or tire tread region **38**. The tire and rim enclose an interior tire cavity **40**.

As shown in FIG. **1** the pump assembly **14** includes a pump passageway **42** that is mounted or located in the sidewall area of the tire, preferably near the bead region. The pump passageway **42** may be formed of a discrete tube made of a resilient, flexible material such as plastic, elastomer or rubber compounds, and is capable of withstanding repeated deformation cycles when the tube is deformed into a flattened condition subject to external force and, upon removal of such force, returns to an original condition. The tube is of a diameter sufficient to operatively pass a volume of air sufficient for the purposes described herein and allowing a positioning of the tube in an operable location within the tire assembly as will be described. Preferably, the tube has an elliptical cross-sectional shape, although other shapes such as round may be utilized.

The pump passageway itself may also be integrally formed into the sidewall of the tire during vulcanization, eliminating the need for an inserted tube. An integrally formed pump passageway is preferably made by building into a selected green tire component such as a chafer, a removable strip made of wire or silicone. The component is built into the tire and cured. The removable strip is then removed post cure to form a molded in or integrally formed pump air passageway.

Hereinafter, the term "pump passageway" refers either to discrete installed tubes or an integrally molded in pump passageway. The location selected for the air passageway within the tire may be within a tire component residing within a high flex region of the tire, sufficient to progressively collapse the internal hollow air passageway as the tire rotates under load thereby conveying air along the air passageway from the inlet to the pump outlet.

The pump passageway **42** has an inlet end **42***a* and an outlet end **42***b* joined together by a compact valve system **200**. As shown, the inlet end **42***a* and the outlet end **42***b* are spaced apart approximately 360 degrees forming an annular pump assembly. The invention is not limited to an annular 360 degree pump, and may be non-annular (ie, less than 360 degrees.)

Compact Valve System **200**

A first embodiment of a compact valve system **200** is shown in FIGS. **5-19**. The compact valve system includes an inlet control valve **400** which functions to regulate and control the inlet flow and exit flow of the pump **42**. FIG. **11** illustrates an exploded view of the compact valve system **200**. Starting from the bottom of the Figure, the compact valve system **200** includes an optional insert **60**, a retainer **80**, a flow controller **300**, an inlet control valve **400** and cap **500**, a spring **600**, and a lid **700**. An optional filter assembly **800** is connected to the compact valve system **200**.

Insert

As shown in FIG. **10**, the compact valve system includes an optional insert **60** that is inserted into a receptacle **64** built in the tire. The receptacle **64** is a raised area or hump formed on the tire inner surface and may optionally include a threaded inner hole, wherein the hump may be built into the tire sidewall using a series of concentric layers of material, such as uncured elastomer, green rubber. A one piece molded shape of rubber or elastomer may also be used instead of the concentric layers. Alternatively, the insert **60** may be inserted into the receptacle prior to vulcanization. The outer insert may be made of green rubber, elastomer, nylon, ultra high molecular weight polyethylene or metal such as brass. The insert is preferably coated with a suitable adhesive such as resorcinol formaldehyde latex (RFL) or commonly referred to as "dip" known to those skilled in the art. The outer surface of the insert may be roughened and coated with the selected RFL. 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 the insert into the rubber of the tire sidewall.

As shown in FIG. **5**B, the optional insert **60** is shaped like a cup and has an interior section formed by an open end facing the tire cavity, a bottom wall **62** opposite the open end and a sidewall **63**. The bottom wall has two male portions **65** and **67** extending from the bottom wall that align and connect to the pump passageways **42***a*, **42***b* for communicating fluid between the insert **60** and pump **42**. Each male portion has a hole therethrough for communicating filtered air to the interior of the valve. The bottom portion also has two opposed holes **68**, **69** for alignment and fluid communication with the pump passageways **42***a*, **42***b*. An optional gasket **70** is positioned on the bottom wall **62** of the insert **60**. The gasket is circular and flat, with holes aligned with the holes **68**, **69** of the insert **60**. The gasket may also have protruding rims around the three holes. As shown in FIG. **5**A, the bottom wall **62** of the insert **60** has a third hole **71** for receiving the male portion **820** of the filter assembly **800**. The outer insert **60** also has a flanged rim portion **61** that surrounds the sidewall **63** with opposed female slots. A lid **700** with two opposed U shaped connectors **710** are received within opposed female slots.

Retainer

The optional outer insert **60** houses a retainer **80**. The retainer **80** is shown in FIGS. **5**A, **5**B, and FIGS. **8**-**10**. The retainer **80** is generally cylindrically shaped, with an alignment key **82** projecting from the outer surface. The alignment key **82** is seated in mating engagement with an alignment slot (not shown) formed in the sidewall of the outer insert **60**. The alignment key **82** ensure that slots **83***a*, **84***a* on the bottom surface **85** of the valve body aligns with holes **68**, **69** of the insert. The bottom surface **85** of the insert further includes a hole **86** for receiving filtered air from the filter assembly **800**. The insert **60** is an optional component that may be eliminated, and the outer surface of the insert **80** may be threaded for reception into the receptacle **64**.

FIG. **9** illustrates a view from the top of the retainer **80** looking down inside the retainer. The bottom surface **81** of the retainer has grooved passageways **83***b*, **86***b*, and **84***b* formed therein. As shown in FIG. **10** an upper plate **87** is positioned over the bottom surface **81**, so that an alignment tab **91** is received in the alignment key **82** of the retainer **80**. The grooved passageways **83***b*, **86***b*, and **84***b* cooperate with the upper plate **87** to channel the flow through the passageways from **83***a*, **84***a*, **86***a* to **83***c*, **84***c*, **86***c*, respectively. Slotted holes **83***a*, **84***a* communicate fluid from the pump **42** to the compact valve system **200**. Fluid from the pump enters slotted holes **83***a*, **84***a* and then are communicated through angled channels **83***b*, **84***b* to port the fluid from the slotted holes **83***a*, **84***a* to locations **83***c*, **84***c*. Flow from locations **83***c*, **84***c* are then directed through port **89**, **90** of upper plate **87**. The upper plate **87** has opposed slots **92**, **93** positioned for alignment with slots **83***a*, **84***a*. Inlet flow from the filter enters the retainer through hole **86***a*, and then through angled channel **86***b* into location **86***c*. Flow from location **86***c* is then routed to central hole **88** of the upper plate **87**.

A flow controller **300** is positioned inside the retainer **80**. As shown in FIG. **21**, the flow control body **302** has an alignment tab **304** positioned for reception in the alignment key **82** of the retainer. The flow controller **300** has directional control valves **306**, **308** and anti return or check valves **310**, **312** as shown in FIG. **21**.

FIG. **7** illustrates a schematic of the tire assembly **10** including the flow controller **300** and its relation to the pump **42** and inlet control valve **400**. The inlet control valve **400** controls whether outside filtered air is permitted to enter the system. If air is needed, the inlet control valve **400** opens and allows air to enter the pump. The flow controller **300** has directional control valves **306**, **308** that are received in respective chambers **307**, **309**. The flow controller further includes two anti return or check valves **310**, **312** mounted in chambers **311**, **313**. The flow controller has a central port **315** that communicates flow from the inlet **86***c* through the flow controller and into communication with the inlet control valve **400**. As shown in FIG. **7**, air from outside the tire enters the filter assembly **800** and enters inlet control valve **400**. If the tire needs air as determined by the inlet control valve **400**, air enters the system through the inlet control valve **400**, and then depending on the direction of the tire rotation, enters through a directional valve **306**, then through the pump and then exits through anti return valve **310** and then into the tire. If the tire is rotating in the opposite direction, air enters through directional valve **308**, is directed into the pump and then into anti return valve **312** and then into tire. Anti return valves **310**, **312** prevent backflow of air from the tire cavity **40** into the pump **42**.

Inlet Control Valve

As shown in FIG. **11**, an inlet control valve **400** is positioned inside the retainer **80** and adjacent to the flow controller **300**. The inlet control valve **400** regulates the intake flow to the pump system. As shown in FIGS. **17**-**18**, the inlet control valve has a housing **402** for housing a circular shaped diaphragm **404**. In a first direction, the housing **402** has three aligned holes on the bottom surface: a central hole **415** and first and second passageways **426**, **428**. The housing also has three aligned holes on the bottom surface in a second direction, perpendicular to the first direction: third passageway **430**, central hole **415** and fourth passageway **432**.

A bottom plate **418** is positioned on the bottom of the inlet control valve housing **402**. The bottom plate **418** has a central hole **420** for alignment with a valve bottom **414** and a central hole **415** of valve housing. As shown in FIG. **17**, the bottom plate **418** has two holes **422**, **424** which align with external passageways **426**, **428** of the inlet control valve housing **402**. Each external passageway **426**, **428** aligns with chamber **307**, **309** respectively of the flow controller **300**. As shown in FIG. **18**, the bottom plate **418** blocks flow from passageways **430**, **432** into the inlet control valve housing. Flow from passageway **430** is routed via curved slot **450** formed in the inlet control housing. The curved slot **450** routs flow from passageway **430** to channel **460** and then through outlet channel **470**.

As shown in FIGS. **17**-**20**, an inlet control valve body **410** is formed of the valve bottom **414**, an optional spacer **416** and a valve top **412**. The valve top **412** has a circular planar region having a first side positioned adjacent a circular diaphragm **404**, and a second side having a central collar **413** extending therefrom. An optional spacer **416** may be received about the collar **413**. The valve bottom **414** has a plug **417** which is received in the collar **413**. The valve bottom **414** is positioned to be seated within central hole **420** of the bottom plate **418**, and positioned to block flow from central hole **415**. A first elastic member **471** has an inner hole **472** that is positioned between the spacer **416** and the valve top **412**. The first elastic member **471** has a plurality of spokes **474** which extend radially from an annular member **476**. The outer ends **478** of the spokes are received between two annular spacers **480**, **482**. An optional second elastic member **484** may have the outer radial ends received between the annular spacer **480** and the bottom plate **418**. The inner portion of the optional second elastic member **484** may be received between the valve bottom and the spacer **416**. The first and second elastic members **471**, **484** are formed of a resilient material such as metal, rubber, elastomer to function as a spring.

As shown in FIG. **14**, the inlet control valve further includes a cover **406** having a hole **408** that is positioned over the diaphragm **404**. The diaphragm **404** is positioned adjacent valve body **410**. An inner cap **500** is positioned over the inlet control valve. The inner cap has an interior hole **502** to allow fluid communication of the diaphragm with the inside cavity of the tire. The cap has a second hole **504** that is in fluid communication with the passageway **470**. A lid **700** is received over the inner cap **500**. A spring **600** is positioned between the lid **700** and the inner cap **500**. The inner cap **500** has a central support column **510** which is received in a central hole **702** of outer cap. The outer cap has aligned holes **704**, **706** with holes **502**, **504**. the lid **700** has two opposed U shaped connectors **710** that are received within opposed female slots of the outer insert **60**.

Filter Assembly

As shown in FIG. **5**A, the filter assembly **800** may be mounted on the outside of the tire, preferably in the lower bead area of the sidewall. The filter assembly is shown having a circular cross-sectional shape with a hard plastic exterior that is shown mounted in the lower sidewall area near the bead. The filter assembly **800** has an interior section **802** filled with porous media **804** suitable for filtering air. The filter assembly **800** has an inlet **810** to receive ambient air. Air travels through the inlet **810** and into the interior section **802** where the air is filtered by the porous media **804**. The air exits the outlet **812** of the interior section and into passageway **814** that extends through a male fitting **816**. The male fitting **816** is received in connector hole **71** of the outer insert and aligned for fluid communication with holes **86** of the retainer and hole **86***a* of the insert.

Pump Operation

The compact valve system **200** controls the flow of air into the pump system. As shown in FIGS. **6** and **14**, the tire cavity pressure is communicated to the diaphragm **404** via holes **704**, **502**, **408**. The tire cavity pressure acts on the diaphragm **404** closing and seating the valve bottom against the central hole **415** so that no air can enter into the compact valve system. The first and second resilient member **471**, **484** counteracts the tire cavity pressure, acting as a spring to bias the valve bottom in the open position. The resilient members are designed to have a set trigger pressure, so that if the tire cavity pressure falls below the trigger pressure, the resilient member(s) bias the valve bottom away from the central hole **415** into the open position. When central port **315** opens, filtered outside air enters the compact valve system **200** via hole **86***a*.

After the air enters the compact valve system **200** via hole **86***a*, the filtered air is routed through angled channel **86***b* into central location **86***c* of the retainer **80** as shown in FIGS. **9**, **16**. As shown in FIG. **14**, flow from central location **86***c* of the retainer is then routed to central hole **88** and then into central port **315** of the flow controller **300**. Air passes through central hole **415** of the inlet control valve and into the inlet control valve interior chamber **403**. As shown in FIG. **12**, the air then passes through bottom plate hole **422**, through first passageway **426** and into flow controller **300**. The flow passes through directional control valve **306**, into chamber **307**, and then exits through aligned holes **92**, **83***a*, **68** into pump inlet **42***a*.

As will be appreciated from FIG. **2**, air pump **42** is shown as a 360 degree pump, with the inlet and outlet co-located. As the tire rotates in a direction **108**, a footprint **100** is formed against the ground surface. A compressive force **104** is directed into the tire from the footprint **100** and acts to flatten a segment **110** of the pump **42** a as shown at numeral **106**. Flattening of the segment **110** of the pump **42** forces a portion of air located between the flattened segment **110** and the compact valve system **200**, towards the compact valve system **200**. As the tire continues to rotate in direction **108** along the ground surface **98**, the pump tube **42** will be sequentially flattened or squeezed segment by segment **110**, **110'**, **110"** in a direction opposite to the tire rotation **108**. The sequential flattening of the pump tube **42** segment by segment causes the column of air located between the flattened segments to be pumped to the pump outlet **42***b*.

The pumped air enters the compact valve system **200** via slot **84***a*. The check valve **308** blocks flow from entering chamber **309**. The pumped air travels from slot **84***a* through channel **84***b* to port **84***c*. The pumped air flows from location **84***c* is then directed through port **90** of upper plate **87**. The pumped air flows through check valve **312** into chamber **313**, and then exits the inlet control valve via fourth passageway **432** of inlet control housing **402**, through channel **460** connected to outlet **470** of the inlet control valve, and then through aligned holes **504** of inner cap and **706** of lid into the tire cavity. The tire will be pumped with air from the pump and inlet control valve assembly **200** until the tire pressure exceeds the trigger pressure. If the tire pressure exceeds the trigger pressure, the valve bottom will seat over central port **415**, and no longer air to enter the system.

If the direction of the tire rotation is reversed, the pump and inlet control valve system will work as described above except for the following differences. Filtered air will enter the system into the inlet control valve chamber **403** and then enter the pump **42***b* via check valve **308** into chamber **309** and exit through hole **84***a* into pump. The pumped air will enter the compact valve system **200** through hole **83***a*. The check valve **306** will block the flow from entering chamber **307**, and force the pumped air through channel **83***b* into hole **83***c* as shown in FIG. **16**. As shown in FIG. **14**, the pumped air passes through directional valve **310**, into chamber **311** and into passageway **430**. Flow from passageway **430** is routed via curved slot **450** formed in the inlet control housing to channel **460** and then through outlet channel **470**. The pumped air then exits as described above into the tire cavity.

As described above, the peristaltic pump assembly may be positioned in the tire sidewall, radially outward of the rim flange surface **26** in the chafer **120**. So positioned, the air tube **42** is radially inward from the tire footprint **100** and is thus positioned to be flattened by forces directed from the tire footprint as described above. The segment that is opposite the footprint **100** will flatten from the compressive force **106** from the footprint **100** pressing the tube segment against the rim flange surface **26**. Although the positioning of the tube **42** is specifically shown as between a chafer **120** of the tire at the bead region **34** and the rim surface **26**, it is not limited to same, and may be located at any region which undergoes compression, such as anywhere in the sidewall or tread.

From the forgoing, it will be appreciated that the subject invention may be used with a secondary tire pressure monitoring system (TPMS) (not shown) of conventional configuration that serves as a system fault detector. The TPMS may be used to detect any fault in the self-inflation system of the tire assembly and alert the user of such a condition.

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 is:

1. A tire having a pump and valve assembly comprising:

a. the tire having a tire cavity, and a first and second sidewall extending respectively from first and second tire bead regions to a tire tread region;

b. said tire having a pump passageway, said pump passageway having an inlet end and an outlet end and being operative to allow a portion of the pump passageway to close and open the pump passageway,

c. the valve assembly having a valve housing, wherein a diaphragm is mounted in the valve housing forming an interior chamber, and wherein the diaphragm is responsive to the pressure of the tire cavity;

d. said interior chamber having a first hole in fluid communication with the inlet end of the pump passageway, and a second hole in fluid communication with the outlet end of the pump passageway, said interior chamber having a third hole in fluid communication with the outside air;

e. said valve housing having a passageway in fluid communication with the tire cavity and the outlet end of the pump,

f. said valve assembly further including an inlet control valve having a valve bottom positioned over the third hole and operative to open and close the third hole;

g. wherein the inlet control valve has a first end connected to the diaphragm; and

h. wherein a resilient member is positioned in the interior chamber of the valve housing, and wherein the resilient member biases the valve bottom into the open position.

2. The tire of claim **1** wherein the resilient member has an inner hub, and a plurality of spokes which extend radially from the hub.

3. The tire of claim **2** wherein the inner hub is connected to the inlet control valve.

4. The tire of claim **2** wherein the inner hub is connected to the inlet control valve bottom.

5. The tire of claim **1** wherein a one way valve is positioned between the first hole and the inlet end of the pump passageway.

6. The tire of claim **1** wherein a one way valve is positioned between the pump outlet end and the passageway in the valve housing.

7. The tire of claim **1** wherein a filter assembly is in fluid communication with the outside air.

8. The tire of claim **1** wherein the inlet control valve further includes a second resilient member.

9. The tire of claim **1** wherein the resilient member is made of metal.

10. A tire having a bidirectional pump and valve assembly comprising:

a. the tire having a tire cavity, and a first and second sidewall extending respectively from first and second tire bead regions to a tire tread region;

b. said tire having a pump passageway, said pump passageway having a first end and a second end and being operative to allow a portion of the pump passageway to close and open the pump passageway when the tire is rotated in a first direction or second direction opposite said first direction,

c. the valve assembly having a valve housing, wherein a diaphragm is mounted in the valve housing forming an interior chamber, and wherein the diaphragm is responsive to the pressure of the tire cavity;

d. said interior chamber having a first hole in fluid communication with a first chamber, a second hole in fluid communication with the outside air; and a third hole in fluid communication with a second chamber;

e. said valve assembly further including an inlet control valve positioned in the interior chamber, wherein the inlet control valve is positioned over the second hole and operative to open and close the second hole to allow outside air to enter;

f. wherein a resilient member is positioned in the interior chamber of the valve housing and biases the inlet control valve into the open position;

g. wherein said first chamber has a one way valve positioned therein, and said first chamber is in fluid communication with the pump passageway first end and the interior chamber,

h. wherein said second chamber has a one way valve positioned therein, and said second chamber is in fluid communication with the pump passageway second end and the interior chamber;

i. wherein the valve housing has a third chamber, wherein said third chamber is in fluid communication with the tire cavity and a pump passageway first end, and said third chamber has a one way valve positioned therein; and

j. wherein the valve housing has a fourth chamber, wherein said fourth chamber is in fluid communication with the pump passageway second end and the tire cavity, wherein a one way valve is positioned in the fourth chamber.

11. The tire of claim **10** wherein the inlet control valve is connected to the diaphragm.

12. The tire of claim **10** wherein the one way valve of the first chamber prevents flow from entering the interior chamber.

13. The tire of claim **10** wherein the one way valve of the second chamber prevents flow from entering the interior chamber.

14. The tire of claim **10** wherein the one way valve of the third chamber prevents flow from the tire cavity from entering the pump passageway.

15. The tire of claim **10** wherein the one way valve of the fourth chamber prevents flow from the tire cavity from entering the pump passageway.

16. The tire of claim **10** wherein a filter is positioned between the outside air and the second hole.

17. The tire of claim **10** wherein the valve housing has a channel which routes flow from the pump passageway second end to the third chamber.

18. The tire of claim **10** wherein the valve housing has a channel which routes flow from the pump passageway first end to the tire cavity.

19. A tire having a bidirectional pump and valve assembly comprising:

a. the tire having a tire cavity, and a first and second sidewall extending respectively from first and second tire bead regions to a tire tread region;

b. said tire having a pump passageway, said pump passageway having a first end and a second end and being operative to allow a portion of the pump passageway to close and open the pump passageway when the tire is rotated in a first direction or second direction opposite said first direction,

c. the valve assembly having a valve housing, said valve housing having a first port in fluid communication with a first end of a pump passageway, and a second port in fluid communication with a second end of a pump passageway;

d. wherein a diaphragm is mounted in the valve housing forming an interior chamber, and wherein the diaphragm is responsive to the pressure of the tire cavity;

e. said valve housing further including a first chamber GAR wherein the first chamber has a one way valve positioned therein, said first chamber having an inlet in fluid communication with the interior chamber, and an outlet in fluid communication with the first port;

f. said valve housing further including a second chamber, wherein the second chamber has an inlet and an outlet, wherein the outlet is in fluid communication with the air outside the tire;

g. Said valve housing further including a third chamber, wherein the third chamber has a one way valve positioned therein, and said third chamber has an inlet in fluid communication with the interior chamber and an outlet in fluid communication with the second port;

h. said valve assembly further including an inlet control valve positioned in the interior chamber, wherein the inlet control valve is positioned over the inlet of the second chamber and operative to open and close the inlet to allow outside air to enter the interior chamber;

i. wherein a resilient member is positioned in the interior chamber of the valve housing, and being connected to the inlet control valve, wherein the resilient member biases the inlet control valve into the open position;

k. wherein the valve housing has a fourth chamber, said fourth chamber has a one way valve positioned therein; wherein said fourth chamber has an outlet in fluid communication with the tire cavity and an inlet in fluid communication with pump passageway second end,

l. and wherein the valve housing has a fifth chamber, wherein a one way valve is positioned in the fifth chamber, wherein said fifth chamber has an inlet end in fluid communication with the pump passageway first end and a second end in fluid communication with the tire cavity.

20. The tire of claim **19** wherein the inlet control valve is connected to the diaphragm.

21. The tire of claim **19** wherein the one way valve of the first chamber prevents flow from entering the interior chamber.

22. The tire of claim **19** wherein the one way valve of the third chamber prevents flow from entering the interior chamber.

23. The tire of claim **19** wherein the one way valve of the fourth chamber prevents flow from the tire cavity from entering the pump passageway.

24. The tire of claim **19** wherein the one way valve of the fifth chamber prevents flow from the tire cavity from entering the pump passageway.

25. The tire of claim **19** wherein a filter is positioned between the outside air and the third hole.

26. The tire of claim **19** wherein the valve housing has a channel which routes flow from the pump passageway second end to the inlet of the fourth chamber.

27. The tire of claim **19** wherein the valve housing has a channel which routes flow from the outlet of the fifth chamber to the tire cavity.

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