US 20180222252A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2018/0222252 A1**

Hennig (43) **Pub. Date: Aug. 9, 2018**

(54) **STEER AXLE HIGH-TEMPERATURE WARNING SYSTEM**

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(21) Appl. No.: **15/704,965**

(22) Filed: **Sep. 14, 2017**

Related U.S. Application Data

(63) Continuation of application No. 14/980,659, filed on Dec. 28, 2015, now Pat. No. 9,789,730, which is a continuation of application No. 14/536,326, filed on Nov. 7, 2014, now Pat. No. 9,254,712, which is a continuation of application No. 13/808,940, filed on Apr. 23, 2013, now Pat. No. 8,910,683, filed as application No. PCT/US2011/044879 on Jul. 21, 2011.

(60) Provisional application No. 61/368,960, filed on Jul. 29, 2010.

Publication Classification

(51) **Int. Cl.**

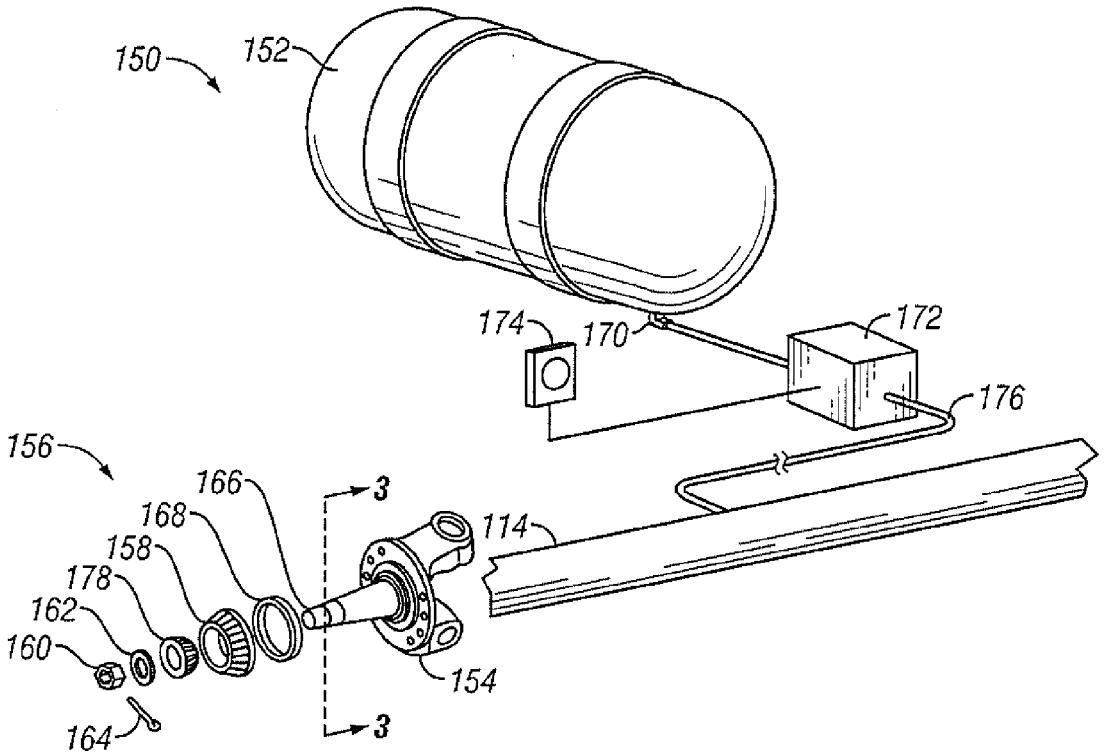
B60B 35/00	(2006.01)
F16K 17/38	(2006.01)
B60C 23/00	(2006.01)
B60C 23/20	(2006.01)
B60C 29/06	(2006.01)
B60T 17/22	(2006.01)
B60T 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***B60B 35/003*** (2013.01); ***F16K 17/383*** (2013.01); ***B60C 23/002*** (2013.01); *B60B 2900/731* (2013.01); ***B60C 23/20*** (2013.01); ***B60C 23/003*** (2013.01); ***B60C 29/06*** (2013.01); ***B60T 17/22*** (2013.01); ***B60T 5/00*** (2013.01); *Y10T 137/1797* (2015.04); *Y10T 137/8326* (2015.04); *Y10T 137/8158* (2015.04)

(57) **ABSTRACT**

A high temperature warning system for a vehicle steer axle an air pressure supply, a normally-closed valve in fluid communication with pressure supply, a heat sensitive control capable of opening the normally-closed valve upon a predetermined temperature, the heat sensitive control mounted adjacent to the wheel end assembly in a heat exchange relationship therewith, and a warning system connected to the air pressure supply for actuation upon opening of the normally-closed valve.



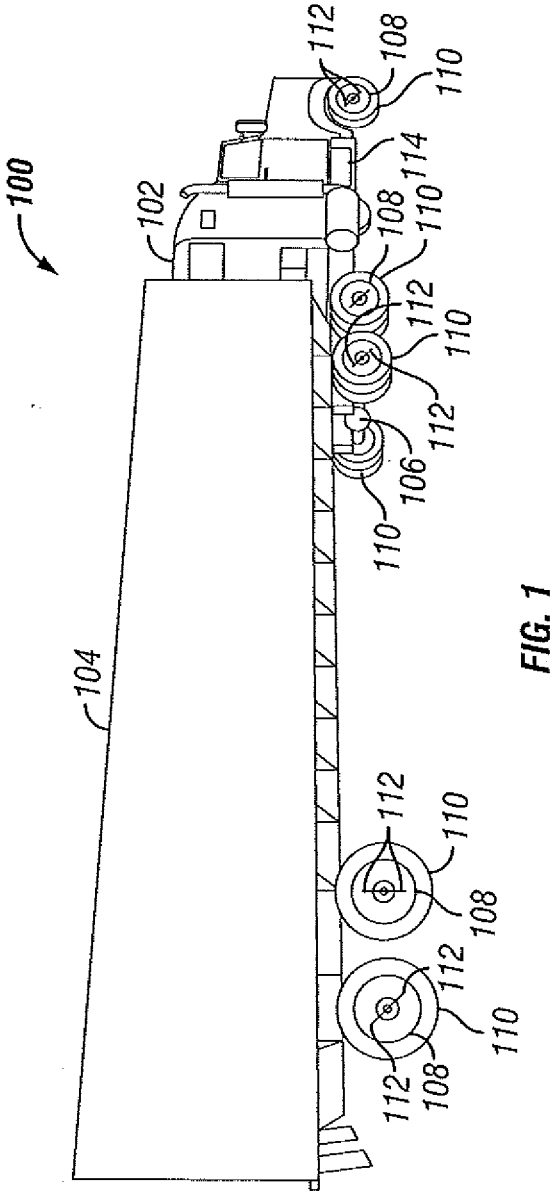


FIG. 1

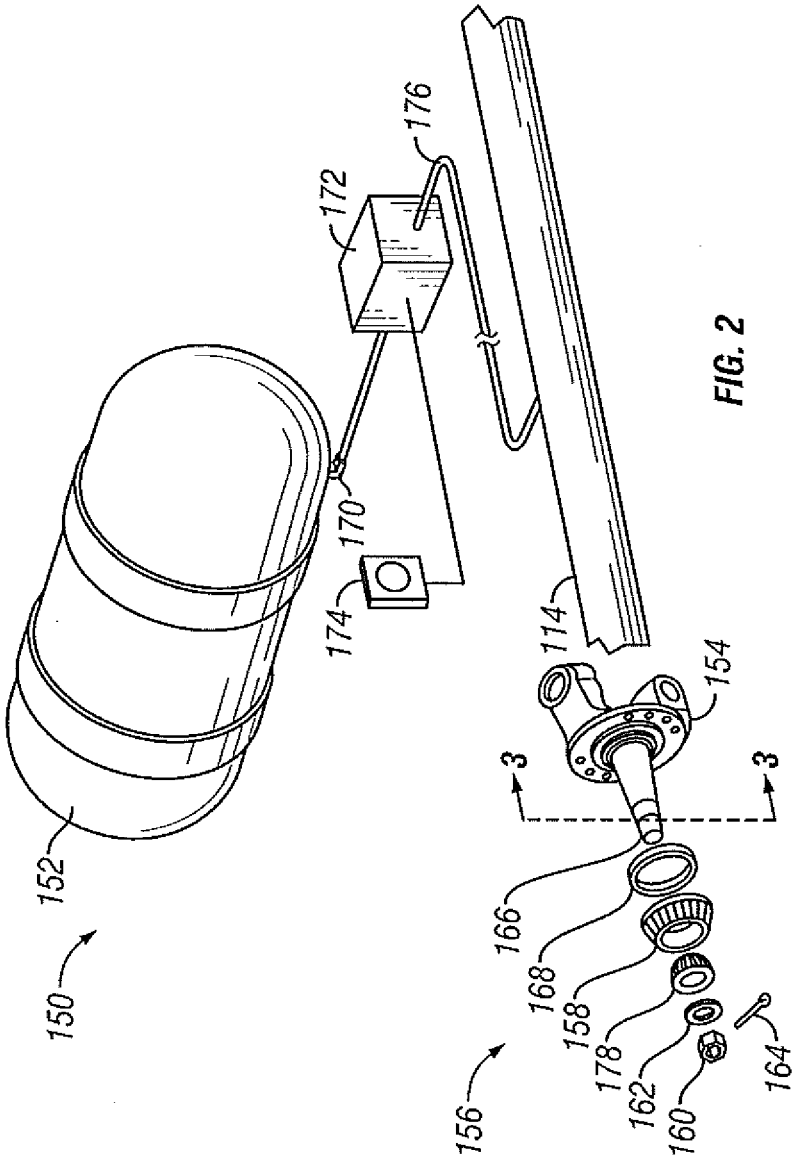

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FIG. 2

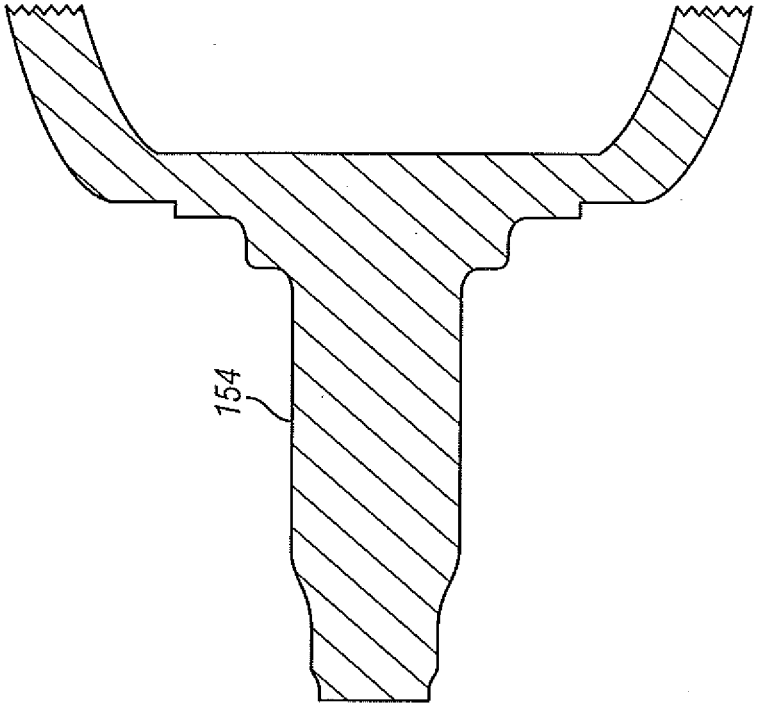

FIG. 3

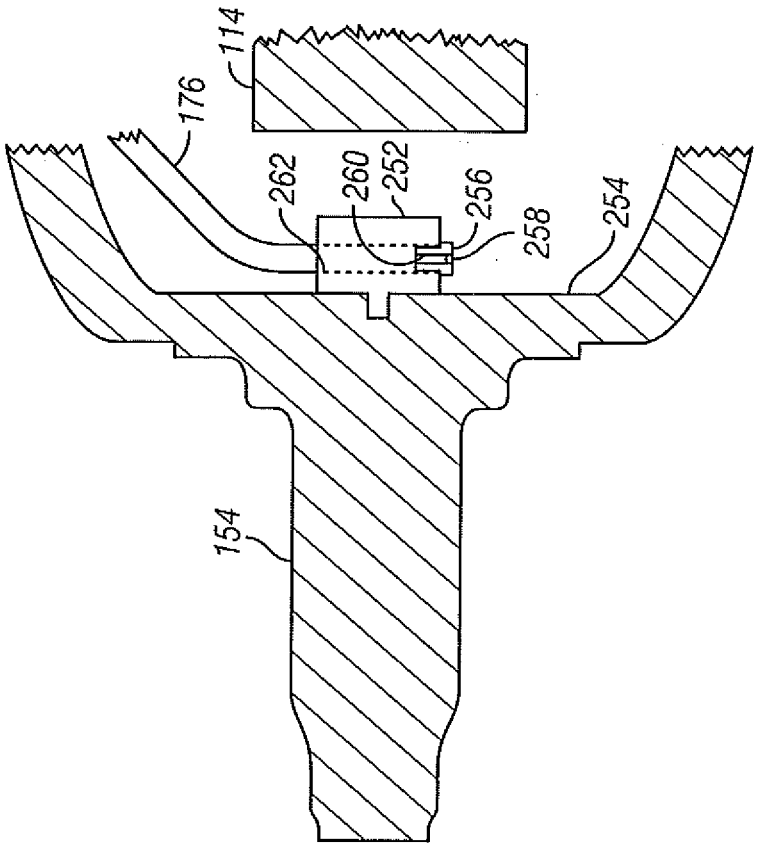

FIG. 4

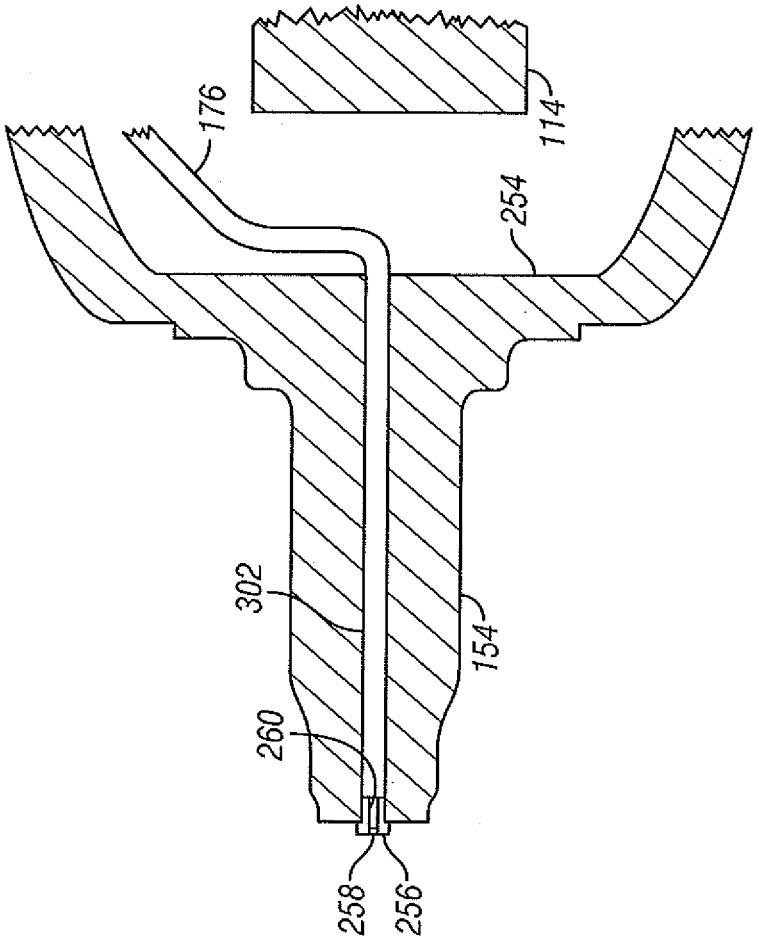

FIG. 5

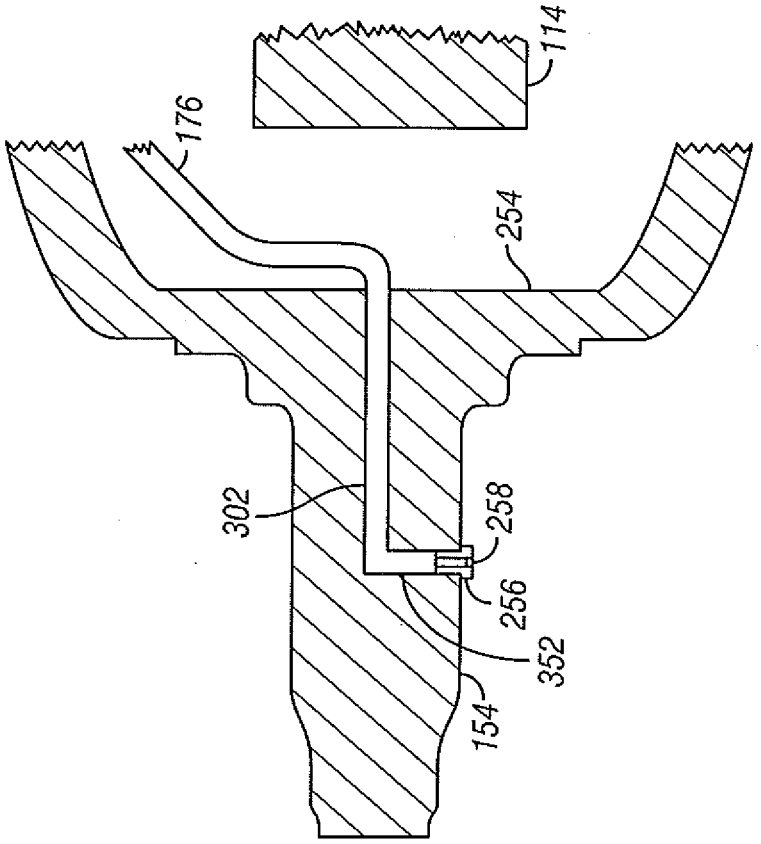

FIG. 6

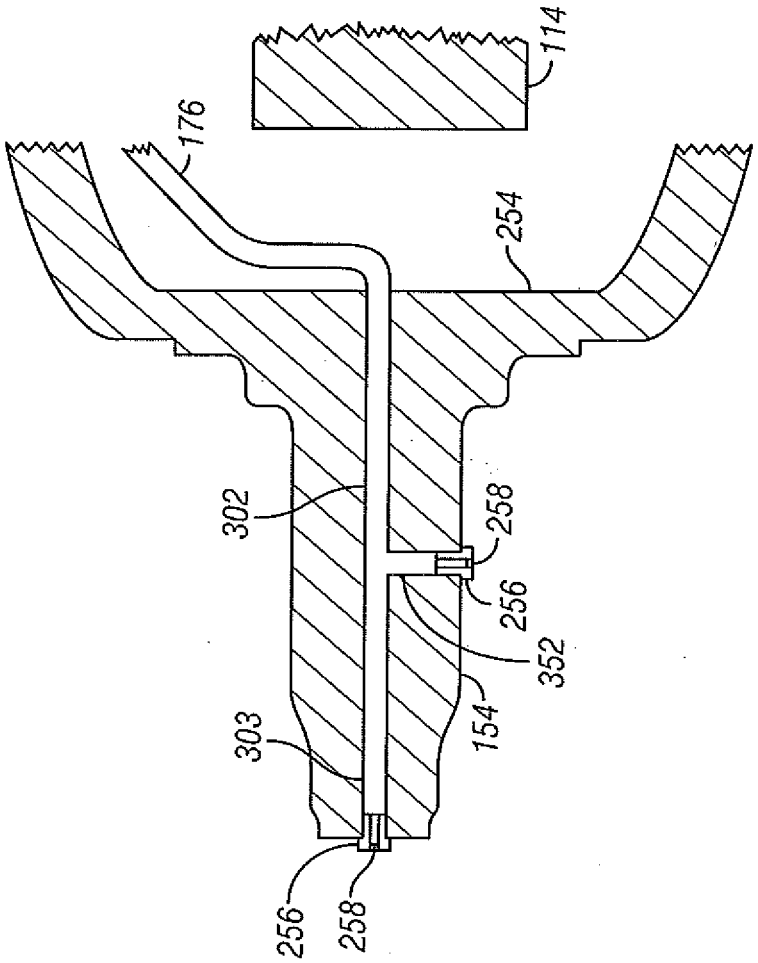

FIG. 7

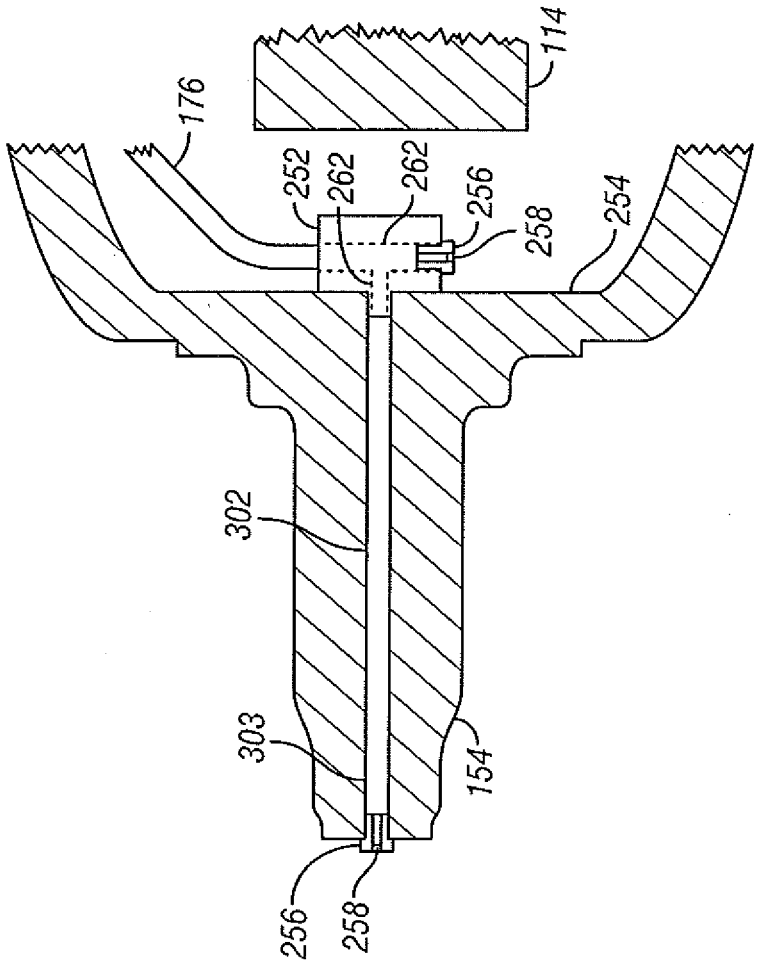

FIG. 8

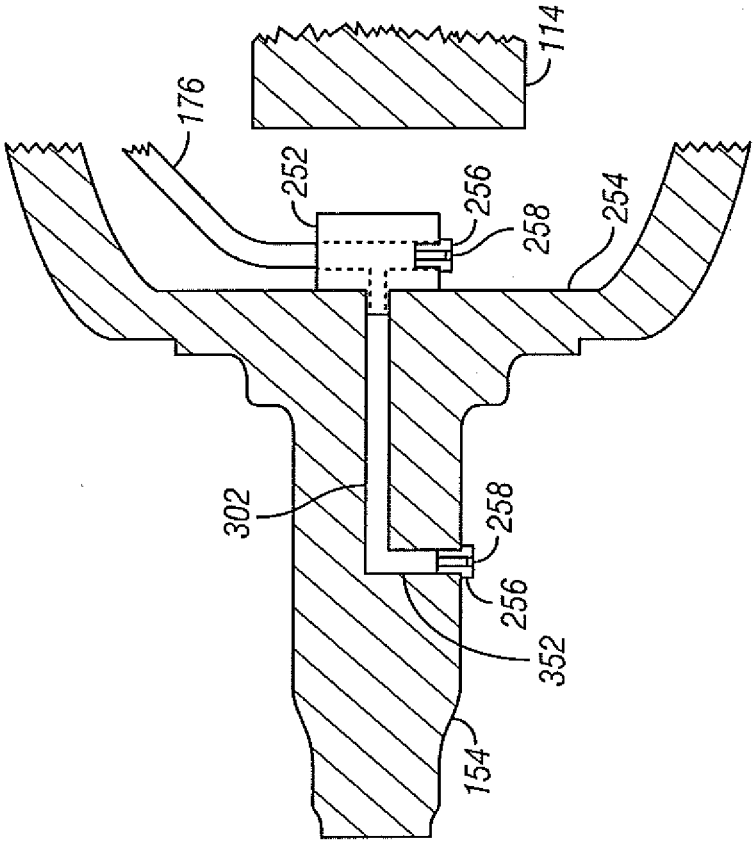

FIG. 9

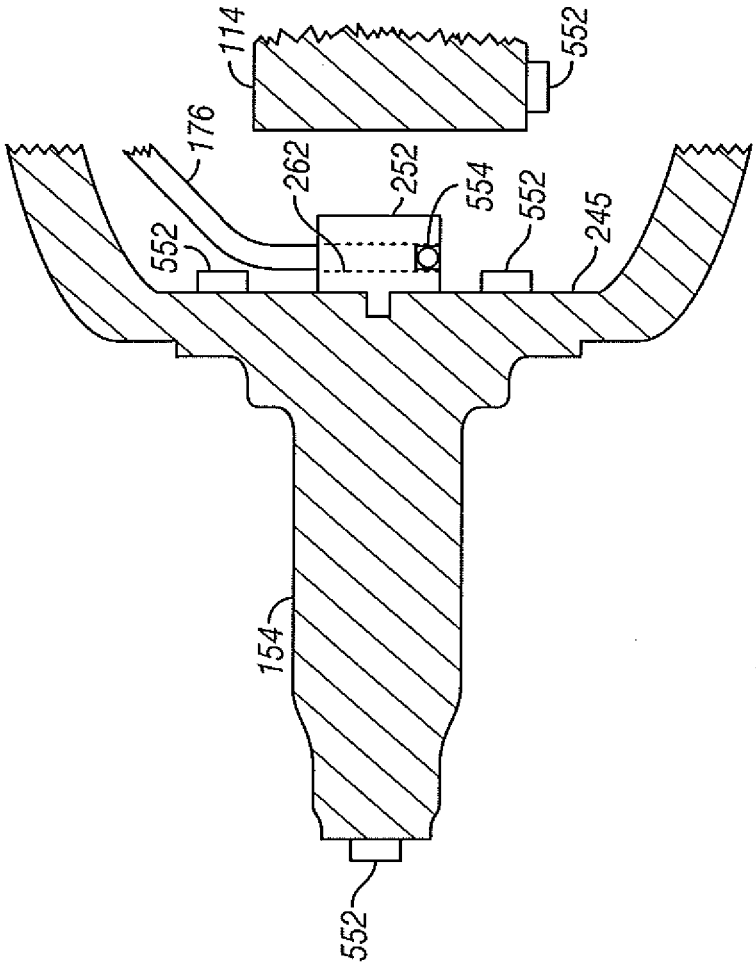

FIG. 10

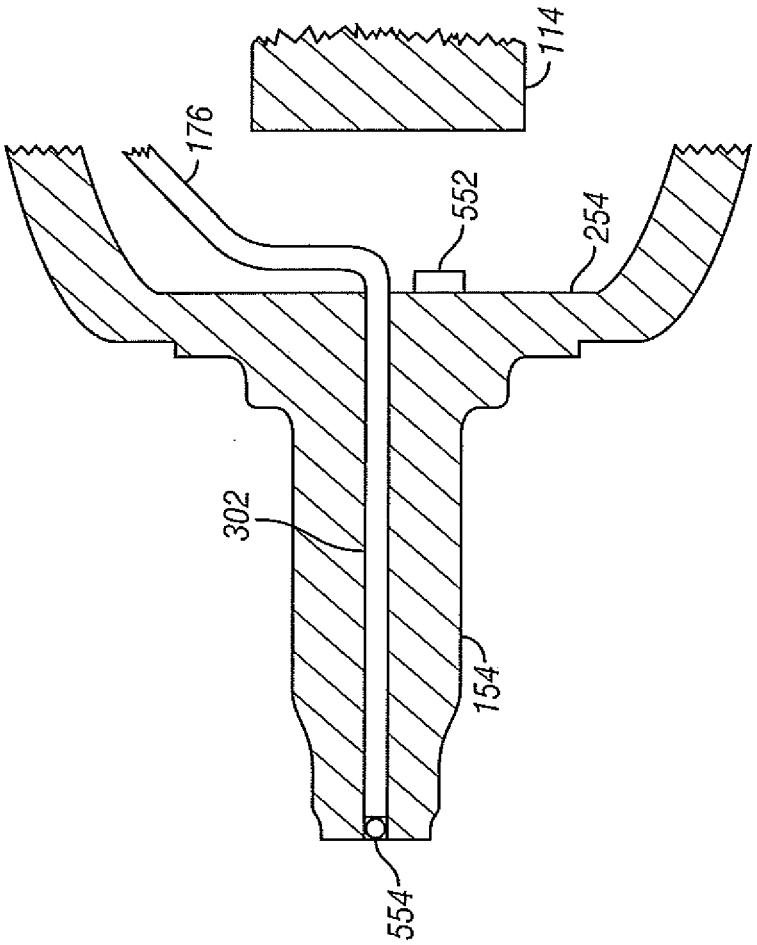

FIG. 11

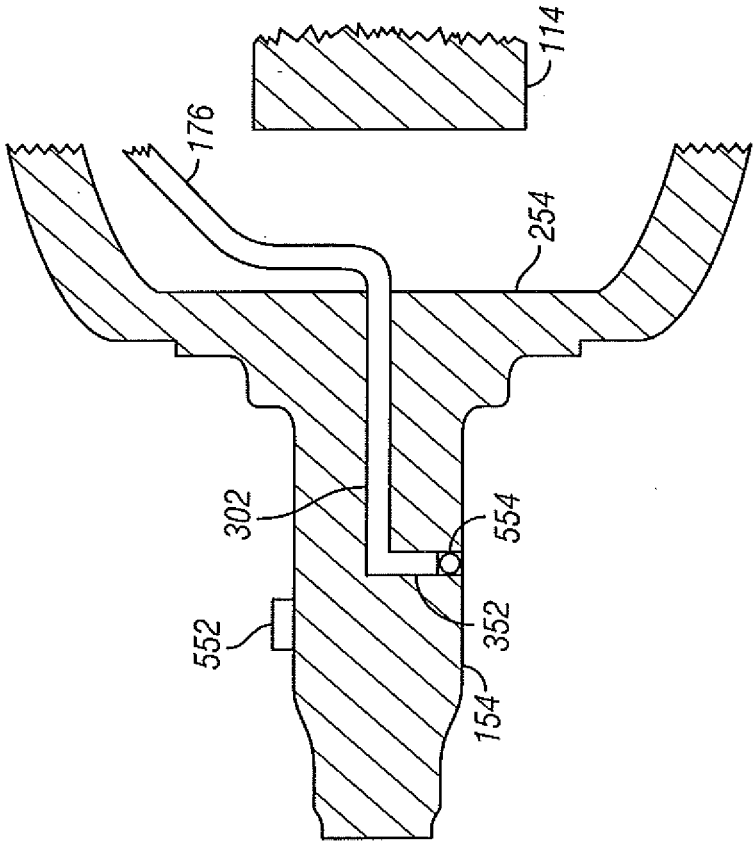

FIG. 12

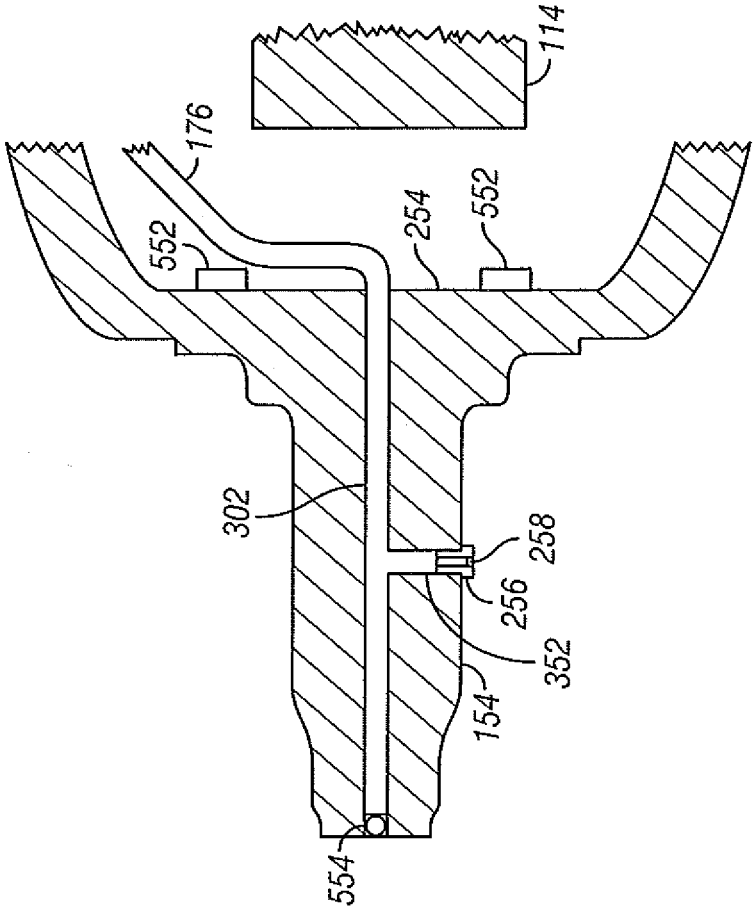

FIG. 13

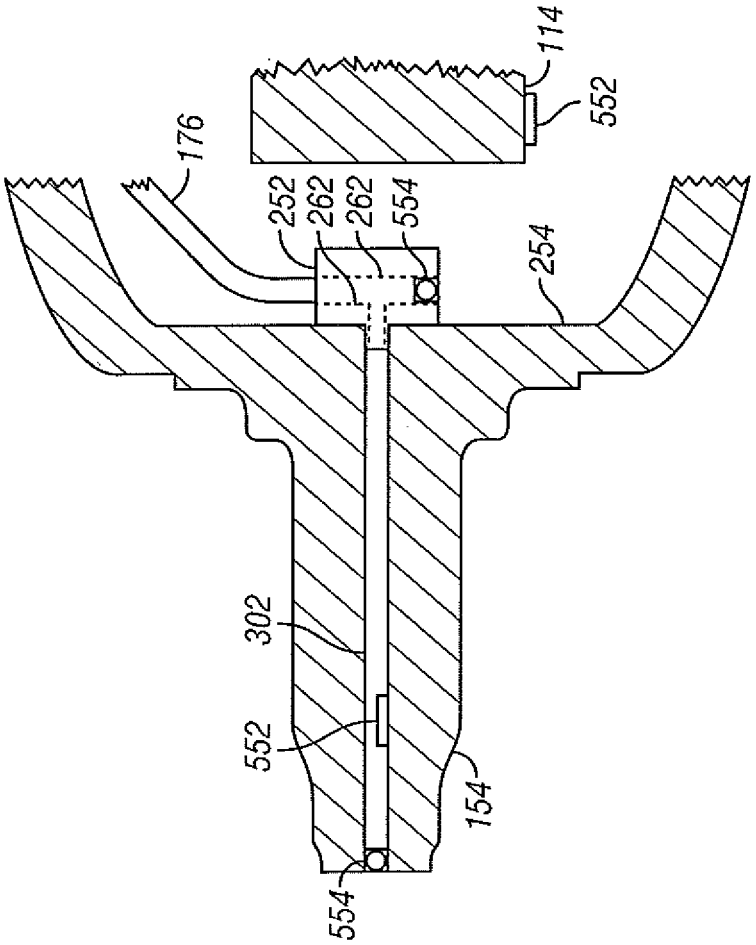

FIG. 14

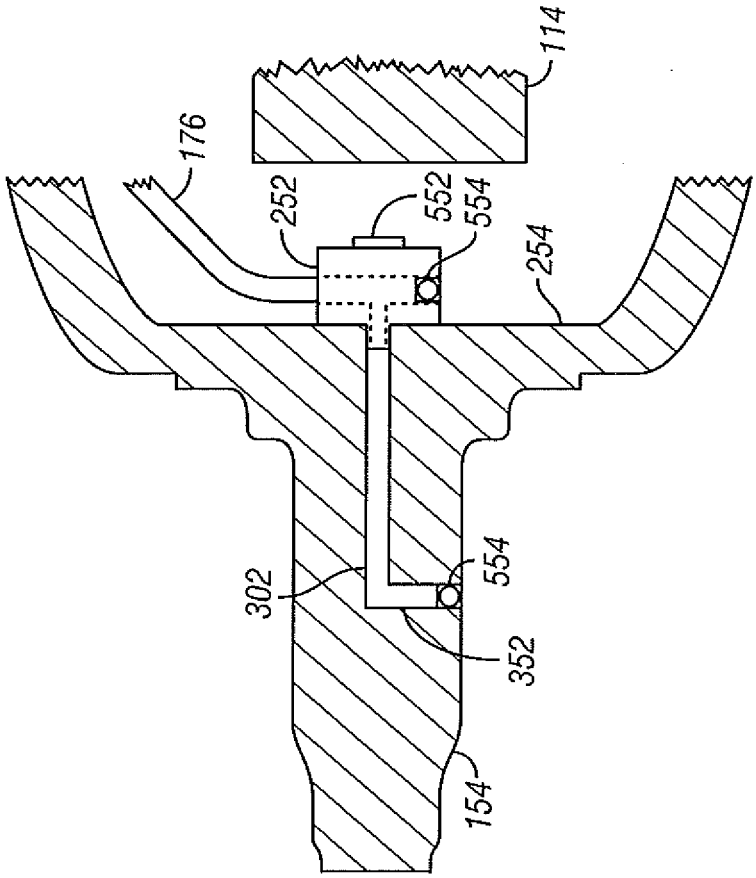

FIG. 15

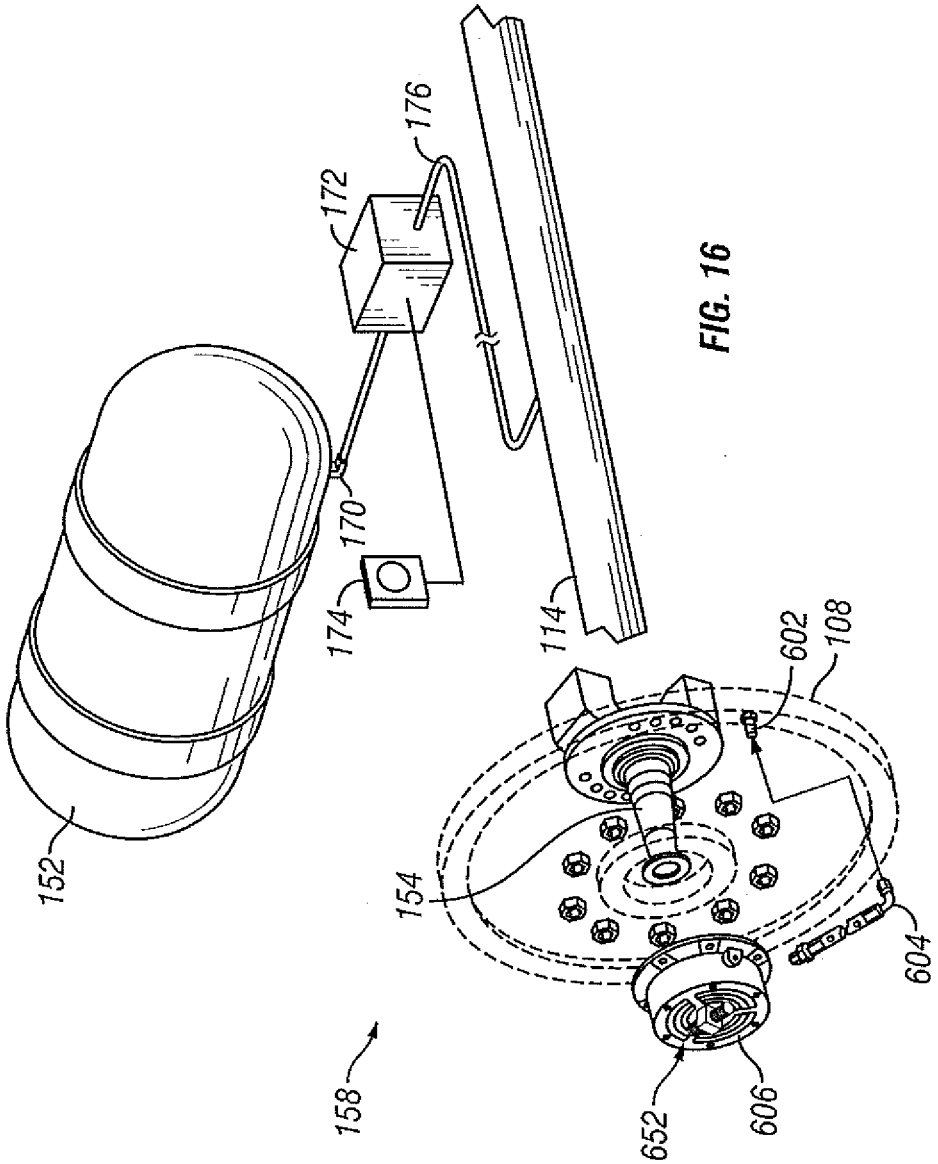

FIG. 16

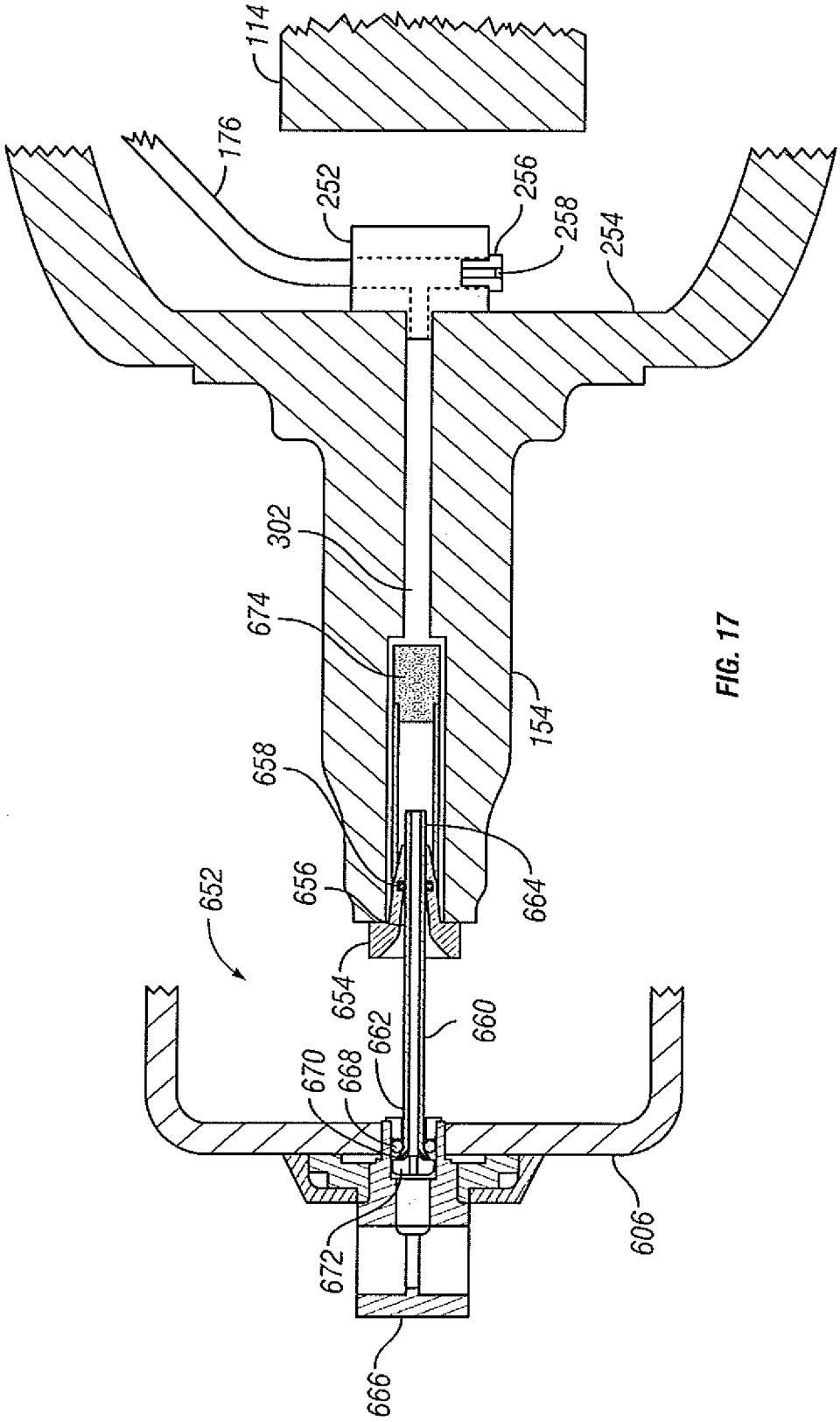
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FIG. 17

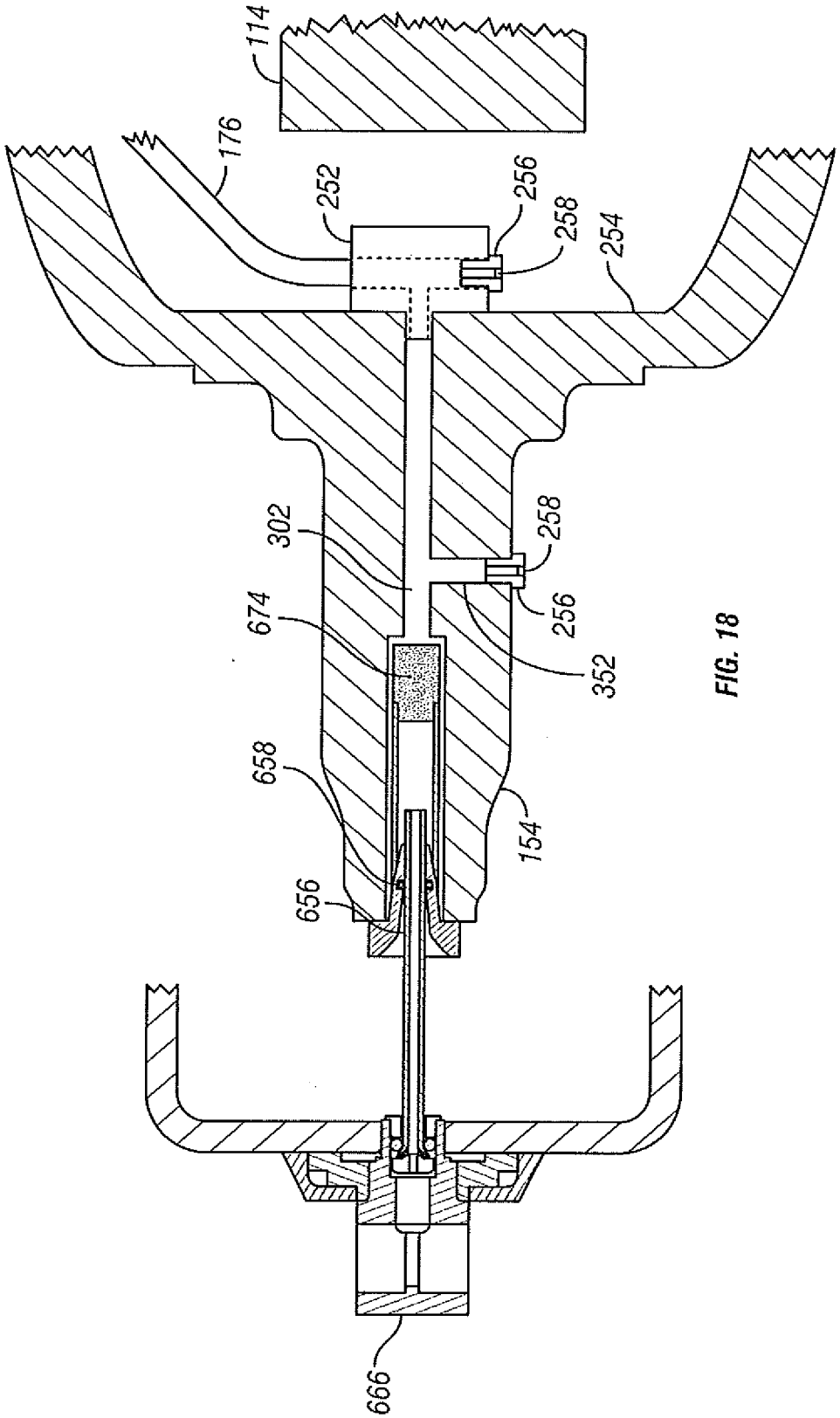

FIG. 18

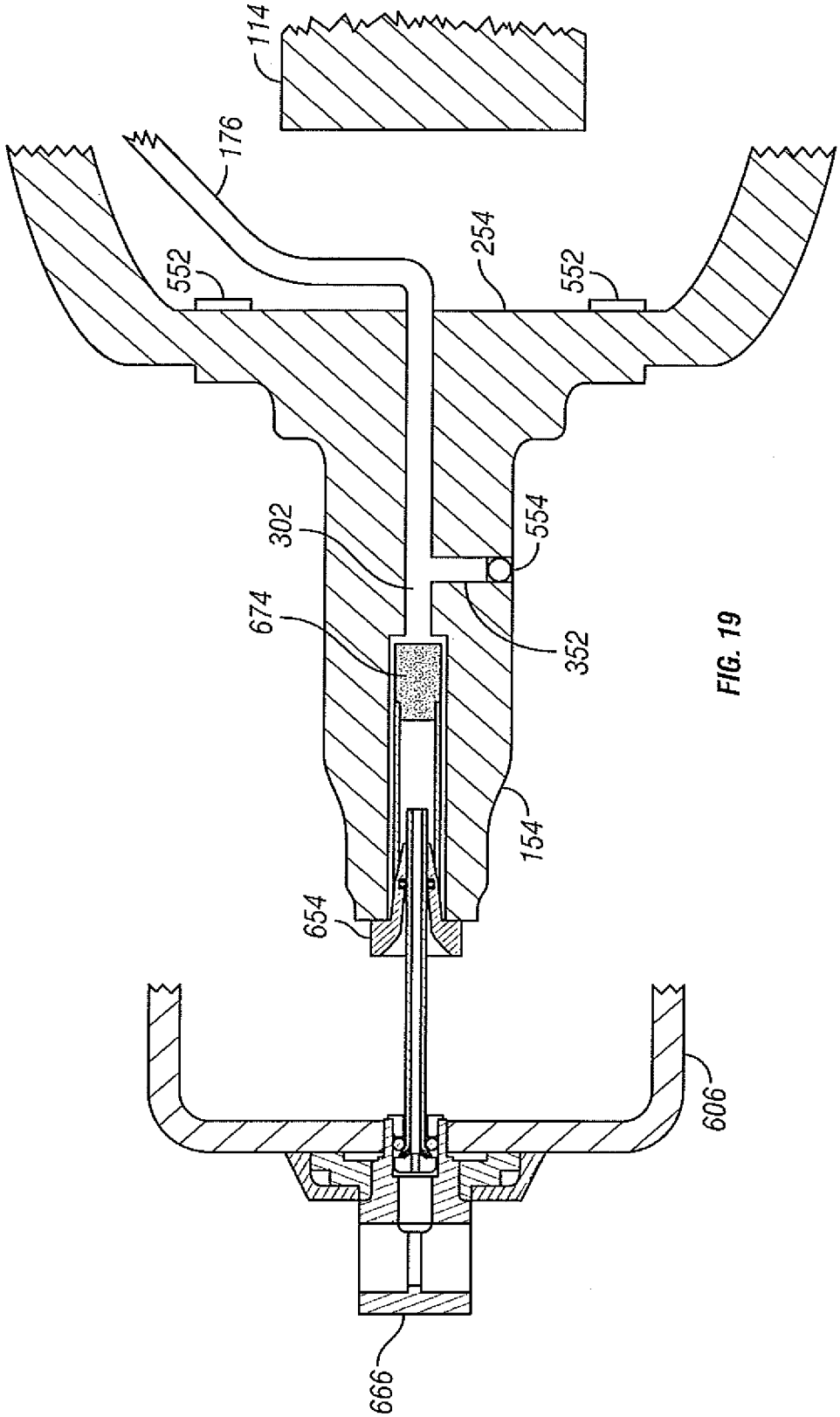

FIG. 19

STEER AXLE HIGH-TEMPERATURE WARNING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION DATA

[0001] This application claims priority to U.S. Provisional Patent Application No. 61/368,960, entitled "Steer-Axle High-Temperature Warning System" filed Jul. 29, 2010, which is hereby entirely incorporated by reference.

FIELD

[0002] The disclosed system relates generally to high temperature warning systems for vehicle steer axles.

BACKGROUND

[0003] In the event of a failure associated with the wheel end, such as a bearing failure or brake failure, elements of the wheel end can heat up and reach high temperatures very quickly. When these high temperatures are reached by the wheel end, tires and/or lubricant may ignite and cause the wheel to lock up or the vehicle to burn. Due to the intense heat caused by a wheel end failure, it is also possible that the wheel can detach from the axle.

SUMMARY

[0004] A high temperature warning system for a steer-axle wheel end assembly, the system comprising: an air pressure supply, a normally-closed valve in sealed fluid communication with the air pressure supply, a heat sensitive control capable of opening the normally-closed valve upon a predetermined temperature, the heat sensitive control mounted on or near the steer-axle wheel end assembly in a heat exchange relationship therewith, and a warning indicator connected to the air pressure supply for actuation upon opening of the normally-closed valve.

[0005] An automatic tire inflation and high-temperature warning system for a steer-axle wheel end assembly comprising a spindle, bearings mounted to the spindle, a hub rotatably mounted to the bearings, a wheel mounted to the hub, and a pneumatic tire mounted to the wheel, the system comprising: an air pressure supply, a rotary union mounted to the spindle and in sealed communication with the air pressure supply and with the tire, a normally-closed valve in sealed fluid communication with the air pressure supply, a heat sensitive control capable of opening the normally-closed valve upon a predetermined temperature, the heat sensitive control mounted on or near the steer-axle wheel end assembly in a heat exchange relationship therewith, and a warning indicator connected to the air pressure supply for actuation upon opening of the normally-closed valve.

[0006] A high temperature warning system for a steer-axle wheel end assembly, the system comprising: a normally-closed valve capable of sealed fluid communication with an air pressure supply, a heat sensitive control mountable on or near the steer-axle wheel end assembly in a heat exchange relationship therewith, and capable of connecting to the normally-closed valve and opening the normally-closed valve upon a predetermined temperature, and warning indicator connected to the air pressure supply for actuation upon opening of the normally-closed valve.

[0007] A high temperature warning system for a steer-axle wheel end assembly, the system comprising: an air pressure supply, a electrically-operated normally-closed valve in sealed fluid communication with the air pressure supply, a thermal electric switch capable of opening the normally-closed valve upon a predetermined temperature, the thermal electric switch mounted on or near the steer-axle wheel end assembly in a heat exchange relationship therewith, and a warning indicator connected to the air pressure supply for actuation upon opening of the electrically-operated normally-closed valve.

BRIEF DESCRIPTION OF THE FIGURES

[0008] FIG. **1** illustrates one embodiment of a vehicle that may use a steer-axle high-temperature warning system.

[0009] FIG. **2**. illustrates an exploded view of one embodiment of a steer-axle high-temperature warning system.

[0010] FIG. **3** illustrates a cut-away view of one embodiment of a wheel spindle.

[0011] FIG. **4** illustrates a cut-away side view of one embodiment of a steer-axle high-temperature warning system.

[0012] FIG. **5** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system.

[0013] FIG. **6** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system.

[0014] FIG. **7** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system.

[0015] FIG. **8** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system.

[0016] FIG. **9** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system.

[0017] FIG. **10** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system.

[0018] FIG. **11** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system.

[0019] FIG. **12** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system.

[0020] FIG. **13** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system.

[0021] FIG. **14** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system.

[0022] FIG. **15** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system.

[0023] FIG. **16** illustrates a partially exploded view of one embodiment of a steer-axle high-temperature warning system with an automatic tire inflation system.

[0024] FIG. **17** illustrates a cut-away side view of another embodiment of a steer-axle high-temperature warning system with an automatic tire inflation system.

[0025] FIG. **18** illustrates a cut-away, side view of another embodiment of a steer-axle high-temperature warning system with an automatic tire inflation system.

[0026] FIG. **19** illustrates a cut-away, side view of another embodiment of a steer-axle high-temperature warning system with an automatic tire inflation system.

DETAILED DESCRIPTION

[0027] As may be seen in FIG. **1**, a vehicle **100** may comprise a truck **102** and trailer **104**. The truck **102** may include one or more drive axles **106** as part of the vehicle's powertrain. The truck **102** may further include a steer axle **114** having pivoting hubs that provide steering capability for the vehicle **100**. The trailer **104** may include one or more fixed axles (not shown). Each axle may have one or more wheels **108** mounted thereto with a tire **110** mounted to each wheel **108**. Of course, other types of steerable vehicles, such as cars and buses may be provided with the high temperature warning system disclosed herein.

[0028] The vehicle **100** may be provided with a pressurized air supply (not shown) used to provide pressurized air to brakes (not shown) and/or to an automatic tire inflation system (indicated with air hoses **112**). The steer-axle high-temperature warning system (shown in more detail in FIGS. **4-19**) may warn a driver when the steer axle **114** and/or steer axle wheel end reach a predetermined temperature.

[0029] Referring now primarily to FIG. **2**, a vehicle may include a wheel-end high-temperature warning system **150** and a steer axle **114** having a wheel spindle **154** on which a wheel end assembly **156** may be mounted. The wheel end assembly **156** may include a hub (not shown) which may rotate on inner bearings **158** and outer bearings **178**. A wheel **108**, tire **110** (as shown in FIG. **1**) and hubcap may be mounted to the hub. A brake drum (not shown) may be integrally formed with the hub, or otherwise mounted to the hub. The wheel end assembly **156** may also include other suitable parts which are not shown but may be monitored by the wheel-end high-temperature warning system **150**.

[0030] The outer bearings **178** may be retained on the wheel spindle **154** by a spindle nut **160**. A washer **162** may be mounted between the spindle nut **160** and outer bearing **178**. A cotter pin **164** may be inserted through a receiving hole **166** in the end of the wheel spindle **154** so as to prevent the spindle nut **160** from becoming unscrewed from the wheel spindle **154**. The wheel spindle **154** may be pivotally mounted to the front steer axle **114** via a knuckle post assembly (not shown).

[0031] An oil seal **168** may be mounted to the wheel spindle **154** adjacent the inner bearing **158** so as to prevent loss of lubricant through the inner bearing **158**. A hub cap **606** (as shown in FIGS. **16-19**) may be mounted to the hub, thus generally sealing the bearings **158** and **178** from debris and preventing loss of lubrication.

[0032] If the bearings **158** and **178**, brakes, or other elements of the wheel end fail, the temperature in the bearings **158** and **178**, brake drum, wheel spindle **154**, or other wheel end elements may reach in a temperature high enough to ignite the tires **110** and bearing lubricant. Such heat may also be sufficiently high to cause the wheel end assembly **156** to detach from the wheel spindle **154**. The disclosed high-temperature warning system may warn the vehicle operator of high temperatures well before the tires ignite or bearings melt, or some other dangerous high-temperature related condition arises in the wheel-end.

[0033] The high-temperature warning system **150** may include an air pressure supply **152**, such as that typically provided on a truck **102** or vehicle **100** for various purposes such as air brakes; a pressure protection valve **170**; a flow switch **172**; and an indicator or warning system light **174**. An air conduit **176** may connect the air pressure supply **152** to one or more normally-closed valves **256** (as shown in the embodiments of FIGS. **4-19**).

[0034] FIG. **3** shows a cross section of the exemplary wheel spindle **154** of FIG. **2**. As may be seen in FIG. **4**, the air conduit **176** may be connected to a valve block **252** mounted to the inner face **254** of the wheel spindle **154**. In some embodiments, the valve block **252** may be comprised of metal or any other suitable thermally-conductive material, and may mounted to the wheel spindle **154**, such as by threadable attachment. The valve block **252** may be suitably configured so as to allow the valve block **252** to remain at or near the temperature of the wheel spindle **154** when mounted thereto. A normally-closed valve **256** may be mounted to the valve block **252** in fluid communication with the air conduit **176** through a channel **262** which connects the air conduit **176** with the normally-closed valve **256**.

[0035] The normally-closed valve **256** may be opened by a heat sensitive control. In one embodiment, the heat sensitive control may be configured to detect temperature and to open the normally-closed valve **256** when a predetermined temperature is measured. A pre-determined temperature may be, for example, a temperature well below the softening or melting point of the bearing materials, or well below the tire melting point. The pre-determined temperature may be set well above the maximum temperatures at which a wheel-end assembly may normally operate so as to avoid false alarms. Thus, when the temperature near the hear sensitive control reaches the predetermined temperature, the heat sensitive control will open the normally-closed valve **256** to allow air to pass through the normally-closed valve **256**.

[0036] The heat sensitive control may be any device which is capable of detecting temperature and either directly or indirectly opening a normally-closed valve in response thereto. For example, in some embodiments, the heat sensitive control is fusible plug **258**, a thermally electric switch **552**, or any other suitable control. The normally-closed valve **256** and the heat sensitive control may be located at separate locations on the vehicle **100**. The heat sensitive control may be mounted in or near the wheel-end assembly in a heat-exchange relationship therewith. In some embodiments the heat sensitive control may be in a conductive heat exchange relationship with the wheel end assembly such that the heat sensitive control detects the approximate temperature of wheel end assembly or specific components thereof, such as the bearings or brakes. For example, the heat sensitive control may be mounted near the wheel end assembly **156** while the normally-closed valve **256** is mounted at or near the air pressure supply **152**. In other embodiments, the heat sensitive control may be mounted near the wheel end assembly **156** while the normally-closed valve **256** is mounted at another point on or near the wheel end assembly **156**, for example as shown in FIGS. **10-15** and **19**. In other embodiments, the heat sensitive control may be included within the normally-closed valve **256** and both the heat sensitive control and the normally-closed valve **256** may be located at the same position at or near the wheel end assembly **156**. For example, in the embodiments of FIGS. **4-9** and **17-18**, the heat sensitive control is contained within the normally-closed valve **256**. In FIGS. **4-9** and **17-18**, the heat sensitive control is a fusible plug **258** comprising of a eutectic alloy. In one embodiment, the fusible plug **258** is placed within an aperture **260** within the normally-closed valve **256**. The fusible plug **258** may seal the aperture **260** by being located within the aperture **260**, as shown in FIG.

4. The fusible plug **258** may open the normally-closed valve **256** upon a predetermined temperature by melting sharply at the predetermined temperature and thus un-sealing the aperture **260** in the normally-closed valve **256**. Thus, the fusible plug **258** may be automatically removed from the aperture **260** when the predetermined temperature is reached, thus opening the normally-closed valve **256**. While any type of fusible plug **258** may be satisfactorily used, one sold under the trademark LEEKPRUF sold by the Mueller Refrigeration Company, Inc., is suitable. In some embodiments, when the eutectic alloy of the fusible plug **258** melts, air may escape from the air pressure supply **152** through the normally-closed valve **256** via air conduct **176**. The escaping air may be detected by the flow switch **172**, which may actuate the warning system light **174** showing FIG. **1**. The warning system light **174** may be positioned within view of the driver of the vehicle **100** to indicate a problem. In other embodiments, air may escape when the normally-closed valve **256** is automatically opened, for example, by a thermal electric switch.

[0037] As may be seen in the embodiments of FIGS. **5-19**, one or more normally-closed valves **256** may be provided in various combinations and at various exemplary locations. Other types of thermally operated, normally-closed valves **256** and heat sensitive controls may also be used. For example, the heat sensitive control may be a thermal electric switch **552** which actuates an electrically-operated normally-closed valve **256** upon a predetermined temperature, as shown in FIGS. **10-15** and **19**. The thermal electric switch **552** may actuate the electrically-operated normally-closed valve **256** by sending an electric signal via wire or wirelessly to the electrically-operated normally-closed valve **256** when the thermal electric switch **552** reaches a predetermined temperature. The electrically-operated normally-closed valve **256** may then receive the signal and open the normally-closed valve **256**. Thus, in some embodiments, the normally-closed valve **256** includes the heat sensitive control **57** (as shown in FIGS. **4-9** and **16-18**) while in other embodiments, the heat sensitive control **57** may be located remotely from the normally-closed valve **256** and may communicate (electronically or otherwise) with and open the normally-closed valve **256** (as shown in FIGS. **10-15** and **19**).

[0038] In the embodiment of FIG. **5**, the wheel spindle **154** may be bored along its central axis to provide an axial channel **302** in fluid communication with the air conduit **176**. A normally-closed valve **256** containing the heat sensitive control, in this embodiment a fusible plug **258** comprising a eutectic alloy, may be threadably mounted in the axial channel **302** at the outer end of the spindle **154**. The air conduit **176** may be sealingly connected to the axial channel **302** at the inner face **254** of the spindle **154**, or may extend through the axial channel **302** and sealingly connect to the normally-closed valve **256**. In some embodiments, when the wheel spindle **154** or surrounding wheel end assembly **156** elements reach a predetermined temperature, the eutectic alloy may melt and open the aperture **260** in the normally-closed valve **256** such that air from the air conduit **176** flows through the aperture **260**. A pre-determined temperature may be, for example, a temperature substantially below the temperature at which bearing lubricant burns or bearings melt.

[0039] In the embodiment of FIG. **6**, a radial channel **352** may extend from the axial channel **302** to an external surface of the spindle **154** so as to allow mounting of a normally-closed valve **256** adjacent the inner bearings **158** and/or outer bearings **178** (shown in FIG. **2**). The normally-closed valve **256** may be sealingly mounted in the radial channel **256** at the external surface of the spindle so as to be in fluid communication with the air conduit **176** such that when the normally-closed valve **256** is opened, air from the air conduit **176** can escape through the normally-closed valve **256**. As shown in the embodiment of FIG. **6**, the air conduit **176** may be sealingly connected from the air pressure supply **152** to the inner face **254** of the wheel spindle **154** so as to supply pressurized air to a normally-closed valve **256** without need for a valve block **252**. In some embodiments, the air conduit **176** may be inserted through the axial channel **302** and/or radial channel **352** to sealingly connect with the normally-closed valve **256** so as to allow sealed fluid communication from the air pressure supply **152** to the normally-closed valve **256**.

[0040] In the embodiment of FIG. **7**, normally-closed valves **256** may be located at one end **303** of the axial channel **302** and in the radial channel **352**. The embodiment of FIG. **7** may not include a valve block **252** but rather the air conduit **176** may sealingly connect to the axial channel **302**. Of course, the air conduit **176** may also extend through the axial and radial channels for sealing connection directly with the normally-closed valves. In this embodiment, the heat sensitive control **258** may be contained within the normally-closed valve **256** and may comprise a fusible plug **258** made of a eutectic alloy.

[0041] In the embodiment of FIG. **8**, the air conduit **176** may sealingly connect with the valve block **252**. Normally-closed valves **256** maybe located at one end **303** of the axial channel **302** and in valve block **252**. The valve block **252** may include channels **262** which allow the air conduit **176** to fluid communication with the axial channel **302** and the normally-closed valves **256**. In this embodiment, the heat sensitive control **258** may be contained within the normally-closed valve **256** and may comprise a fusible plug **258** made of a eutectic alloy.

[0042] In the embodiment of FIG. **9**, normally-closed valves **256** may be mounted in the radial channel **352** in the valve block **252**. In this embodiment, the heat sensitive control **258** may be contained within the normally-closed valve **256** and may comprise a fusible plug **258** made of a eutectic alloy.

[0043] In some embodiments, the air conduit **176** may sealingly connect the air pressure supply **152** to the valve block **252** (as shown in FIG. **9**) or axial channel **302** of the wheel spindle **154** (as shown in FIGS. **5-7**). In some embodiments, the air conduit **176** may run through a hollow front steer axle **114**. In some embodiments, the air conduit **176** may run alongside the front steer axle **114**. In some embodiments, the hollow front steer axle **114** may be bored or plugged at each end (not shown), and the air conduit **176** may be connected to the hollow front steer axle **114** so as to use the hollow front steer axle **114** as part of the air conduit or pressure supply. An air line (not shown) may extend from an axle plug (not shown) to the valve block **252** or inner face **254** of the wheel spindle **154** to provide fluid communication between the air pressure supply **152** and the normally-closed valves **256**.

[0044] Referring now to FIGS. **10-15**, the heat sensitive control may be a thermal electric switch **552** which operates an electric-operated normally-closed valve **554** mounted in

a valve block **252** similarly to the valves of previous embodiments. The thermal electric switch **552** and the electric-operated normally-closed valve **554** may each include a power source, may receive power from an external power source or may not need a power source. In the embodiment of FIG. **10**, thermally electric switches **552** may be mounted at a variety of locations at or near the wheel end assembly **156**. For example, a thermally electric switch **552** may be located at the end of the wheel spindle **154**. Other thermally electric switches **552** may be located on an inner face **254** of the wheel spindle **154**. Yet another thermal electric switch **552** may be located on the steer axle **114**. Each thermal electric switch **552** may communicate with the normally-closed valve **256** which may be an electric-operated normally-closed valve **554**. In some embodiments, when any one of the thermally electric switches **552** reaches a predetermined temperature, it will send a signal to the electric-operated normally-closed valve **554** to cause the electric-operated normally-closed valve **554** to open. In other embodiments, the thermally electric switches **552** may communicate with each other or a central processing unit, and may be configured to communicate with the electric-operated normally-closed valve **554** when a certain number of thermal electric switches **552** have reached a predetermined temperature.

[0045] The embodiment of FIG. **11** includes one electric-operated normally-closed valve **554** which is located in the axial channel **302** and a thermal electric switch **552** which is located on the inner face **254** of the wheel spindle **154**. The embodiment of FIG. **12** includes one electric-operated normally-closed valve **554** which is located in the radial channel **352** and one thermal electric switch **552** which is located on the wheel spindle **154**. The embodiment of FIG. **13** includes two thermally electric switches **552** which are located on the inner face **254** of the wheel spindle **154** and one electric-operated normally-closed valve **554** is located in the axial channel **302**. The embodiment of FIG. **13** also includes one normally-closed valve **256** including a fusible plug **258** made of a eutectic alloy which is located in the radial channel **352**. The embodiment of FIG. **14** includes two electric-operated normally-closed valves **554** and two electric-operated normally-closed valves **554**, one which is located in the axial channel **302** and one which is located on the steer axle **114**. The embodiment of FIG. **15** includes two thermally electric switches **552**, one which is located in the radial channel **352** and one which is located in the valve block **252**, and one thermally electric switch **552** which is located on the valve block **252**.

[0046] Of course, the number and locations of thermal electric switches **552** in the foregoing embodiment should not be viewed as limiting. Other embodiments may include fewer or additional thermally electric switches and normally-closed valves in a variety of other locations in and about the wheel end assembly. Likewise, thermally-operated normally-closed valves may be used in combination with fusible plug normally-closed valves. The valve block **252** may be of any suitable configuration adapted for mounting to the wheel spindle, whether at the inner face **254** or elsewhere. The valve block **252** may be further provided with one or more channels **262** to allow fluid communication from air conduit **176** to one or more normally-closed valves. Furthermore, the radial channel **352** may extend from the axial channel **302** at any point along the axial channel **302**. A wheel spindle may have formed therein more than one axial channel **302** and may have formed therein more than one radial channel **352**.

[0047] The high temperature warning system may provide a stand-alone system for vehicles, or the warning system may be easily adapted for use with an automatic tire inflation system which may also use the air pressure supply **152** and a warning system light **174** shown in FIG. **1**. The high temperature warning system may be used with various types of automatic tire inflation systems, one type of which is shown in the embodiments of FIGS. **16-19** and more fully described and illustrated in U.S. Pat. No. 6,698,482, entitled "Rotary Air Connection With Bearing For Tire Inflation System," which is hereby incorporated by reference. As shown in FIG. **1**, the automatic tire inflation system may be used to control air pressure in one or more of the tires **110** mounted to steer axle **114**, drive axle **106** and trailer axles (not shown). The automatic tire inflation system may include one or more air hoses **112** in fluid communication with each tire **110**. Other automatic tire inflation systems, such as without limitation those disclosed in U.S. Pat. Nos. 7,273,082, 6,325,124, and 6,105,645, and U.S. Pub. App. No. 2009/0283190.

[0048] Now referring to FIGS. **16-17**, a rotary union **652** may be provided for supplying air from an air pressure supply **152** in an automatic tire inflation system through air hoses **604** to the rotating tires (not shown) mounted to wheels **108**. A hub cap **606** may be provided at each end of the wheel spindle **154** for retaining lubricant in the wheel bearings (not shown). An air conduit **176** may supply air to the rotary union **652** through an axial channel **302** in the wheel spindle **154**. The rotary union **652** may be supported and positioned in the center end of the wheel spindle **154**, and may sealingly engage the interior of the wheel spindle **154** if air is injected directly into the axial channel **302** of the wheel spindle **154**.

[0049] As shown more particularly in FIG. **17**, the rotary union **652** may have a first stationary part **654** or stator having a passageway **656** therethrough. The first stationary part **654** may include a filter **674** to remove debris that may be carried through the axial channel **302**. The passageway **656** may be in fluid communication with the air pressure supply **152** through air conduit **176** and, in some embodiments, a valve block **252**. A first rotary seal **658** may be supported in and encircle the passageway **656**. The rotary union **652** may include a rotatable part including a tubular member **660** having a first end **662** and a second end **664**. The second end **664** of the tubular member **660** may be coaxially extendable through and longitudinally and rotationally movable in the passageway **656**, and may sealably engage the first rotary seal **658** and so as to allow sealed fluid communication with the air pressure supply **152**. The first end **662** of the tubular member **660** may be rotatably and sealably connected through a second rotary seal **668** to an air connection **666** or tee-body mounted on the hub cap **606**. The air connection **666** may be provided on the hub cap **606** for communicating air to the tire or tires **110** (seen in FIG. **1**) via an air hose **604** (seen in FIG. **16**) connected to the wheel valves **602** (seen in FIG. **16**). The first end **662** of the tubular member **660** may include a shoulder **670** that co-acts with a bearing **672**. In operation, air may be supplied through the stationary part of the rotary union **652**. The hub cap **606** and air connection **666** may rotate with the wheels **108** relative to the wheel spindle **154**. Air may flow from the

pressure supply **152** through the filter **674** into the stationary part **654** of the rotary union **652**. Air may flow from the stationary part **654** through the tubular member **660** to the tee-body **666**. Air may flow from the tee-body **666** through air hoses **604** and tire valves **602** into the tires. Of course, if the automatic tire inflation system provides for tire deflation, air may flow in the reverse direction as that just described.

[0050] Thus, the automatic tire inflation system of FIGS. **16-19** may include an air pressure supply **152** and a suitable warning system comprising a flow switch **172** and a warning system light **174**, all of which may be used as part of a high temperature warning system as disclosed herein. The use of a normally-closed valve **256** at a location near the wheel bearings **158** and **178** or brake area on the wheel spindle **154** may provide a high temperature warning system. Again, if the wheel spindle **154** reaches a predetermined temperature, the normally-closed valve **256** will open, such as by the melting of a fusible plug **258** in some embodiments, releasing air from the air pressure supply **152** and actuating the warning system light **174** for notification of the operator. Of course, a warning buzzer or audible alarm may be used in place of the light **174**. The operator may quickly determine whether the warning system light **174** indicates a pressure leak in the tires **110** or a high temperature problem in the wheel hub area. In some embodiments, air escaping through a channel formed in the valve **256** may provide an audible warning of high temperature conditions. The valve **256** configuration may thus serve as a warning indicator. Thus, a warning light **174** need not be used, or may be used in conjunction with human-audible or ultrasonic warning indicators.

[0051] Referring now to the embodiment of FIG. **18**, shown including an automatic tire inflation system, additional normally-closed valves **256** may be provided such as in the radial channel **352**. The normally-closed valve **256** may be connected to the air pressure supply **152** through the air conduit **176**.

[0052] Referring now to FIG. **19**, another embodiment is shown, which includes an automatic tire inflation system, and further includes one electric-operated normally-closed valve **554** which, in this embodiment, is operable by two thermally electric switches **552** on the inner face **254** of the wheel spindle **154**. The electric-operated normally-closed valve **554** may be located in a radial channel **352** so as to be adjacent the inner bearings **158** and/or outer bearings **178**. Of course, the thermally electric switches may be placed at other suitable locations, such as on hubcap **606** or on stator **654**.

[0053] Thus, a high-temperature warning system may be readily used in connection with an automatic tire inflation system in a similar manner and configuration as it would be used without an automatic tire inflation system. Any of the embodiments disclosed herein may be equally suitable for implementation as standalone systems or in connection with an automatic tire inflation system.

[0054] Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the invention as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition, or matter, means, methods and steps described in the specification. As one will readily appreciate from the disclosure, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods or steps.

1-13. (canceled)

14. A high temperature warning system for a steer-axle wheel end assembly, the steer-axle wheel end assembly comprising a steer-axle spindle having an outer end, the system comprising:

a pressurized fluid supply;

the steer-axle spindle having a first channel in sealed fluid communication with the pressurized fluid supply;

a first normally-closed valve sealing the first channel, the first normally-closed valve being in sealed fluid communication with the pressurized fluid supply;

a first heat sensitive control capable of opening the first normally-closed valve at a first predetermined temperature, the first heat sensitive control mounted on or near the steer-axle wheel end assembly in a heat exchange relationship therewith; and

a warning indicator configured for actuation upon opening of the first normally-closed valve.

15. The system of claim **14**, the first channel extending to the outer end.

16. The system of claim **15**, the first channel extending from an external surface of the steer-axle spindle to the outer end, the first channel being in sealed fluid communication with the pressurized fluid supply at the external surface.

17. The system of claim **14**, the first channel extending to an external surface of the steer-axle spindle, the first normally-closed valve sealing the first channel at the external surface.

18. The system of claim **14** wherein the first heat sensitive control forms part of the first normally-closed valve.

19. The system of claim **18**, the first heat sensitive control comprising an eutectic alloy capable of melting and opening the first normally-closed valve at the first predetermined temperature.

20. The system of claim **14**, the first normally-closed valve being an electrically-operated normally-closed valve, and the first heat sensitive control being a thermal electric switch.

21. The system of claim **15**, the steer-axle spindle having a central axis about which a wheel may rotate, a portion of the first channel extending approximately along the central axis; the spindle having a second channel formed therein extending from the first channel to the external surface of the spindle; and a second normally-closed valve sealing the second channel, the second heat sensitive control mounted on or near the steer-axle wheel end assembly in a heat exchange relationship therewith, and the second normally closed valve being in sealed fluid communication with the pressurized fluid supply.

22. The system of claim **21**, first heat sensitive control being capable of opening the second normally-closed valve at the first predetermined temperature.

23. The system of claim **21**, further comprising a second heat sensitive control capable of opening the second normally-closed valve at the first predetermined temperature

24. The system of claim **21**, further comprising a second heat sensitive control capable of opening the second normally-closed valve at a second predetermined temperature.

25. The system of claim **24**, the first predetermined temperature and the second predetermined temperature being the same.

26. The system of claim **21**, the second heat sensitive control comprising an eutectic alloy capable of melting and opening the second normally-closed valve at the first predetermined temperature.

27. The system of claim **24**, the second heat sensitive control comprising an eutectic alloy capable of melting and opening the second normally-closed valve at the second predetermined temperature.

28. The system of claim **22**, the first normally-closed valve and the second normally-closed valve each being an electrically operated, the first heat sensitive control being a thermal electric switch controlling the first normally-closed valve and the second normally-closed valve.

29. The system of claim **14**, wherein the warning indicator comprises either a flow switch capable of sensing air flow from the air pressure supply, and a warning light capable of activation by the flow switch; or a sound channel formed in the first normally-closed valve through which air may flow and produce sound audible to humans when the first normally-closed valve opens.

30. The system of claim **17**, the steer-axle wheel end assembly comprising a pneumatic tire, the system further comprising a tire inflation system rotary union in sealed fluid communication with the tire; the first channel further extending to the outer end of the steer-axle spindle, the rotary union being in sealed fluid communication with the first channel at the outer end of the spindle.

31. A high temperature warning system for a steer-axle wheel end assembly, the steer-axle wheel end assembly comprising a steer-axle spindle having an outer end, the system comprising:

a first normally-closed valve configured for sealing a first channel formed in the steer-axle spindle, the first normally-closed valve further configured for sealed fluid communication with a pressurized fluid supply through the first channel; and

a first heat sensitive control capable of opening the first normally-closed valve at a first predetermined temperature, the first heat sensitive control configured for mounting on or near the steer-axle wheel end assembly in a heat exchange relationship therewith.

32. The system of claim **31**, the first heat sensitive control forming part of the first normally-closed valve.

33. The system of claim **32**, the first heat sensitive control comprising an eutectic alloy capable of melting and opening the first normally-closed valve at the first predetermined temperature.

34. The system of claim **31**, the first normally-closed valve being an electrically-operated normally-closed valve, and the first heat sensitive control being a thermal electric switch.

35. The system of claim **31**, further comprising a warning indicator configured for actuation upon opening of the first normally-closed valve.

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