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

(57) A high temperature warning system for a vehicle steer axle 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 sen-

sitive 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.

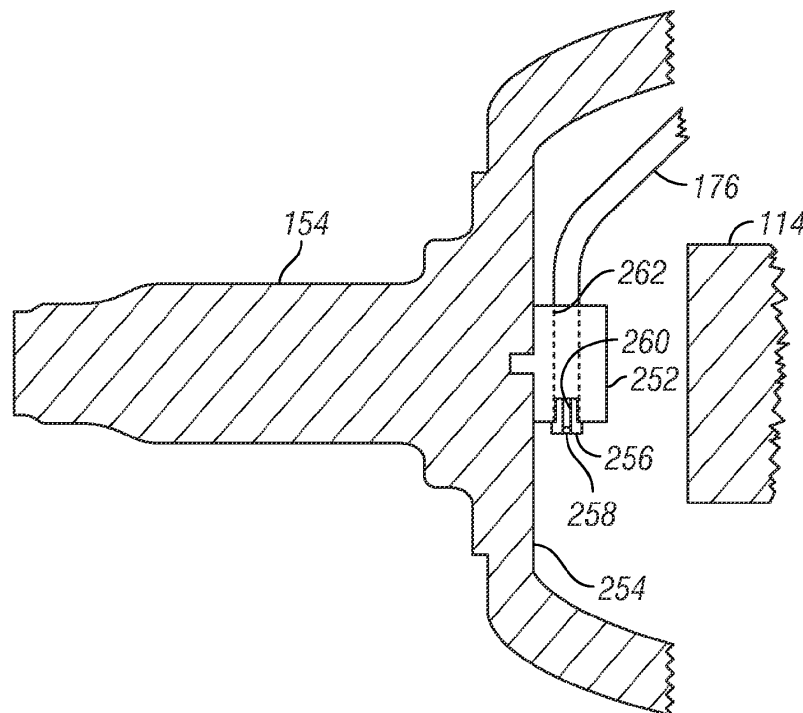


FIG. 4

Description

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 July 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 nor-

mally-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 a 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, an 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.

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

FIG. 3 illustrates a cut-away view of one embodiment of a wheel spindle.

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

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

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

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

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

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

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

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

FIG. 12 illustrates a cut-away side view of another

embodiment of a steer-axle high-temperature warning system.

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

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

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

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

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.

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.

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

[0009] 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.

[0010] 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.

[0011] 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-tempera-

ture warning system 150.

[0012] 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).

[0013] 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.

[0014] 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.

[0015] 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).

[0016] 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 be 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.

[0017] 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 predetermined 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 predetermined 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 heat 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.

[0018] 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 unsealing 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 conduit 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.

[0019] 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).

[0020] 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.

[0021] 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.

[0022] 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.

[0023] In the embodiment of FIG. 8, the air conduit 176 may sealingly connect with the valve block 252. Normally-closed valves 256 may be 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.

[0024] 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.

[0025] 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.

[0026] Referring now to FIGS. 10-15, the heat sensitive control may be a thermal electric switch 552 which op-

erates 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.

[0027] 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.

[0028] 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 combi-

nation 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.

[0029] 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. Patent 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. No. 7,273,082, 6,325,124, and 6,105,645, and U.S. Pub. App. No. 2009/0283190.

[0030] 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.

[0031] 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.

[0032] 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.

[0033] 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.

[0034] 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.

[0035] 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.

[0036] 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.

[0037] The claims of the parent application are reproduced below on pages 15-18. These clauses define preferred embodiments. The applicant reserves the right to pursue protection for the combinations of features set out in these clauses, and/or for any other subject-matter contained in the parent application as filed, either in the present divisional application or in a further application divided from the present divisional application. The claims of the parent application are not the claims of this divisional application.

Preferred embodiments

[0038]

1. 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.

2. The system of clause 1 wherein the heat sensitive control forms part of the normally-closed valve.

3. The system of clause 2 wherein the normally-closed valve comprises a fusible plug and the heat sensitive control comprises a eutectic alloy capable of melting and opening the normally-closed valve upon a predetermined temperature.

4. The system of clause 3, the steer-axle wheel end assembly comprising a spindle having an inner face, the system further comprising a valve block mounted to the inner face of the spindle in a heat exchange relationship therewith, the normally-closed valve mounted to the valve block, and the air pressure supply sealingly connected to the valve block in fluid communication with the normally-closed valve.

5. The system of clause 3, the steer-axle wheel end assembly comprising a spindle having a channel formed therein extending approximately along the central axis of the spindle about which a wheel may rotate, the channel extending from an inner face of the spindle to an outer end of the spindle, and the normally-closed valve is sealingly mounted in the channel at the outer end of the spindle and the air pressure supply is in sealed fluid communication with the normally-closed valve through the channel.

6. The system of clause 3, the steer-axle wheel end assembly comprising a spindle having a first channel formed therein extending approximately along the central axis of the spindle about which a wheel may rotate, and a second channel formed therein extending approximately radially from the first channel to an external surface of the spindle, and the normally-closed valve is sealingly mounted in the second channel at the external surface of the spindle and the air pressure supply is in sealed fluid communication with the normally-closed valve through the first channel and second channel.

7. The system of clause 1, wherein the warning indicator comprises a flow switch capable of sensing air flow from the air pressure supply, and a warning light capable of activation by the flow switch.

8. The system of clause 3, wherein the warning indicator comprises a channel formed in the normally-closed valve through which air may flow and produce sound audible to humans when the normally-closed valve opens.

9. 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:

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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.

10. The system of clause 9, the spindle having a channel formed therein extending approximately along the central axis of the spindle about which a wheel may rotate, the channel extending from an inner face of the spindle to an outer end of the spindle, wherein the rotary union is sealingly mounted in the channel at the outer end of the spindle, and the air pressure supply is in sealed fluid communication with the rotary union through the channel.

11. The system of clause 10, the system further comprising a valve block sealingly mounted the inner face of the spindle in a heat exchange relationship therewith and in fluid communication with the channel, the normally-closed valve mounted to the valve block, and the air pressure supply sealingly connected to the valve block in fluid communication with the normally-closed valve and channel.

12. 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
 a warning indicator connected to the air pressure supply for actuation upon opening of the normally-closed valve.

13. 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.

Claims

1. A high temperature warning system for a steer-axle wheel end assembly, the system comprising a steer-axle spindle (154) having an inner face (254) and a free end, a pressurized fluid supply (152), a first normally-closed valve (256, 554), a first heat sensitive control (258, 552) capable of opening the first normally-closed valve (256, 554) at a predetermined temperature and a warning indicator (174) connected to the pressurized fluid supply (152) and actuable upon opening of the first normally-closed valve (256, 554),
 the first normally-closed valve (256, 554) in sealed fluid communication with the pressurized fluid supply (152),
 the first heat sensitive control (258, 552) mounted to or near the steer-axle wheel end assembly in a heat exchange relationship therewith.
2. The system of claim 1 wherein the first heat sensitive control (258, 552) is mounted:
 to the steer-axle spindle (154); or
 to the inner face (254) of the steer-axle spindle (154); or
 to the free end of the steer-axle spindle (154); or
 near the steer-axle spindle (154).
3. The system of claim 1, further comprising:
 a valve block (252) mounted to the inner face (254) of the spindle in a heat exchange relationship therewith, and
 the first normally-closed valve (256, 554) mounted to the valve block, and the pressurized fluid supply (152) sealingly connected to the valve block in fluid communication with the normally-closed valve (256, 554).
4. The system of claim 3, further comprising:
 the steer-axle spindle forming a channel (302) along the central axis of the steer-axle spindle (154) and in sealed fluid communication with the pressurized fluid supply (152) at the inner face (254), and
 a second normally-closed valve (256, 554) mounted to the steer-axle spindle (154) in sealed fluid communication with the pressurized fluid supply (152) through the channel (302).

5. The system of claim 4, wherein the channel (302) extends from the inner face (254) to:
- the free end of the steer-axe spindle (154), the second normally-closed valve (256, 554) being sealingly mounted to the channel at or near the free end of the steer-axe spindle (154); or an external surface of the steer-axe spindle (154), the second normally-closed valve (256, 554) being sealingly mounted to the channel at the external surface of the steer-axe spindle (154).
6. The system of claim 4, further comprising a second heat sensitive control (258, 552) capable of opening the second normally-closed valve (256, 554) at a predetermined temperature.
7. The system of claim 6, wherein the first heat sensitive control (258) forms part of the first normally-closed valve (256, 554) and the second heat sensitive control (258) forms part of the second normally-closed valve (256, 554), optionally wherein the first heat sensitive control (258) comprises a eutectic alloy capable of melting and opening the first normally-closed valve (256, 554) upon reaching the predetermined temperature, and the second heat sensitive control (258) comprises a eutectic alloy capable of melting and opening the second normally-closed valve (256, 554) upon reaching the predetermined temperature.
8. The system of claim 3, further comprising:
- the steer-axe spindle forming a channel (302) along the central axis of the steer-axe spindle (154) and extending from the inner face (254) to the free end of the steer-axe spindle (154), the channel (302) being in sealed fluid communication with the pressurized fluid supply (152) at the inner face (254), and a rotary union (652) sealingly mounted to the channel at the outer end of the steer-axe spindle (154), the rotary union (652) being in sealed communication with the pressurized fluid supply (152) and with a tire.
9. The system of claim 8, wherein the channel (302) also extends from the inner face (254) to an external surface of the steer-axe spindle (154), the system further comprising a second normally-closed valve (256, 554) mounted to the steer-axe spindle (154) in sealed fluid communication with the pressurized fluid supply (152) through the channel (302), optionally wherein the first heat-sensitive control (258, 552) is mounted to the inner face (254) of the steer-axe spindle (154) or to the valve block (252).
10. The system of claim 8, wherein the channel (302) also extends from the inner face (254) to an external surface of the steer-axe spindle (154), the system further comprising a second normally-closed valve (256, 554) mounted to the steer-axe spindle (154) in sealed fluid communication with the pressurized fluid supply (152) through the channel (302) and the system further comprises a second heat sensitive control (258, 552) capable of opening the second normally-closed valve (256, 554) at a predetermined temperature, optionally wherein the second heat-sensitive control (258, 552) is mounted to the inner face (254) of the steer-axe spindle (154) or to the valve block (252).
11. The system of claim 8, wherein the channel (302) also extends from the inner face (254) to an external surface of the steer-axe spindle (154), the system further comprising a second normally-closed valve (256, 554) mounted to the steer-axe spindle (154) in sealed fluid communication with the pressurized fluid supply (152) through the channel (302) and the system further comprises a second heat sensitive control (258, 552) capable of opening the second normally-closed valve (256, 554) at a predetermined temperature; wherein the first heat sensitive control (258) forms part of the first normally-closed valve (256, 554) and the second heat sensitive control (258) forms part of the second normally-closed valve (256, 554); and optionally, wherein the first heat sensitive control (258) comprises a eutectic alloy capable of melting and opening the first normally-closed valve (256, 554) upon reaching the predetermined temperature, and the second heat sensitive control (258) comprises a eutectic alloy capable of melting and opening the second normally-closed valve (256, 554) upon reaching the predetermined temperature.
12. The system of claim 1, further comprising:
- the steer-axe spindle forming a channel (302) along the central axis of the steer-axe spindle (154) and in sealed fluid communication with the pressurized fluid supply (152) at the inner face (254), and the first normally-closed valve (256, 554) mounted to the steer-axe spindle (154) in sealed fluid communication with the pressurized fluid supply (152) through the channel (302).
13. The system of claim 12, wherein the channel (302) extends from the inner face (254) to:
- the free end of the steer-axe spindle (154), the first normally-closed valve (256, 554) being sealingly mounted to the channel at or near the free end of the steer-axe spindle (154); or

an external surface of the steer-axle spindle (154), the first normally-closed valve (256, 554) being sealingly mounted to the channel at or near the external surface of the steer-axle spindle (154). 5

14. The system of claim 12, wherein the first heat-sensitive control (552):

is mounted to the inner face (254) of the steer-axle spindle (154); or 10
 is disposed in the channel (302);
 is mounted to an external surface of the steer-axle spindle (154); or
 forms part of the first normally-closed valve (256, 554) and comprises a eutectic alloy capable of melting and opening the first normally-closed valve (256, 554) upon reaching the predetermined temperature. 15
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15. The system of claim 12, wherein the channel (302) extends from the inner face (254) to the free end of the steer-axle spindle (154), the channel (302) being in sealed fluid communication with the pressurized fluid supply (152) at the inner face (254), and 25
 wherein the channel (302) also extends from the inner face (254) to an external surface of the steer-axle spindle (154), the system further comprising a second normally-closed valve (256, 554) mounted to the steer-axle spindle (154) in sealed fluid communication with the pressurized fluid supply (152) through the channel (302), and 30
 the system further comprising a rotary union (652) sealingly mounted to the channel at outer end of the steer-axle spindle (154), the rotary union (652) being in sealed communication with the pressurized fluid supply (152) and with a tire. 35

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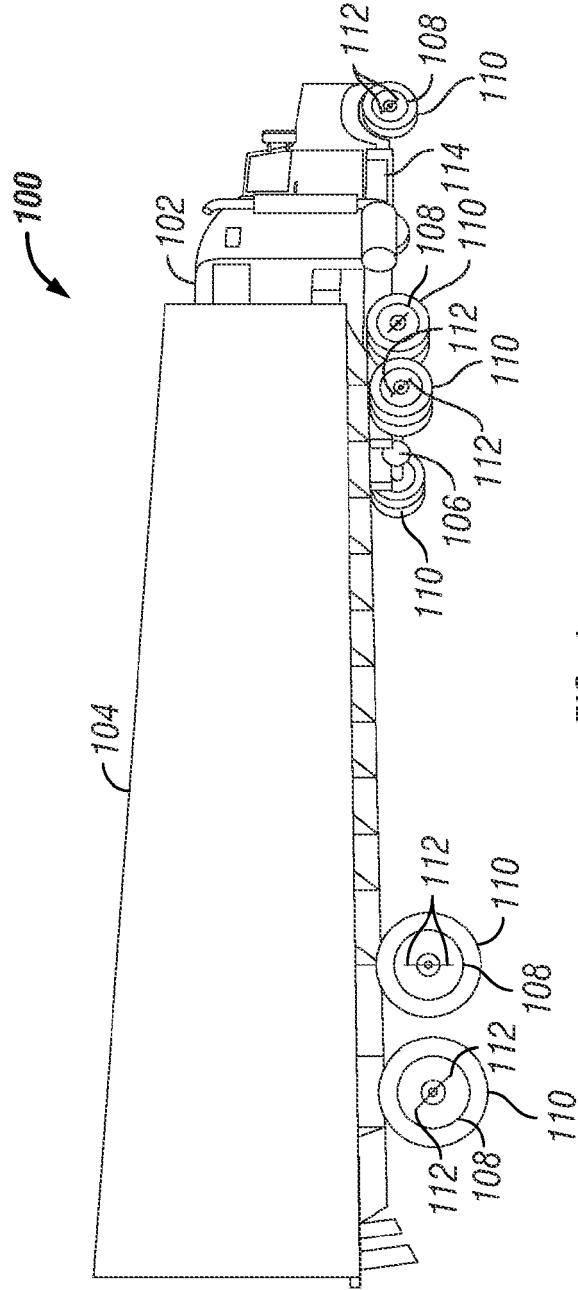


FIG. 1

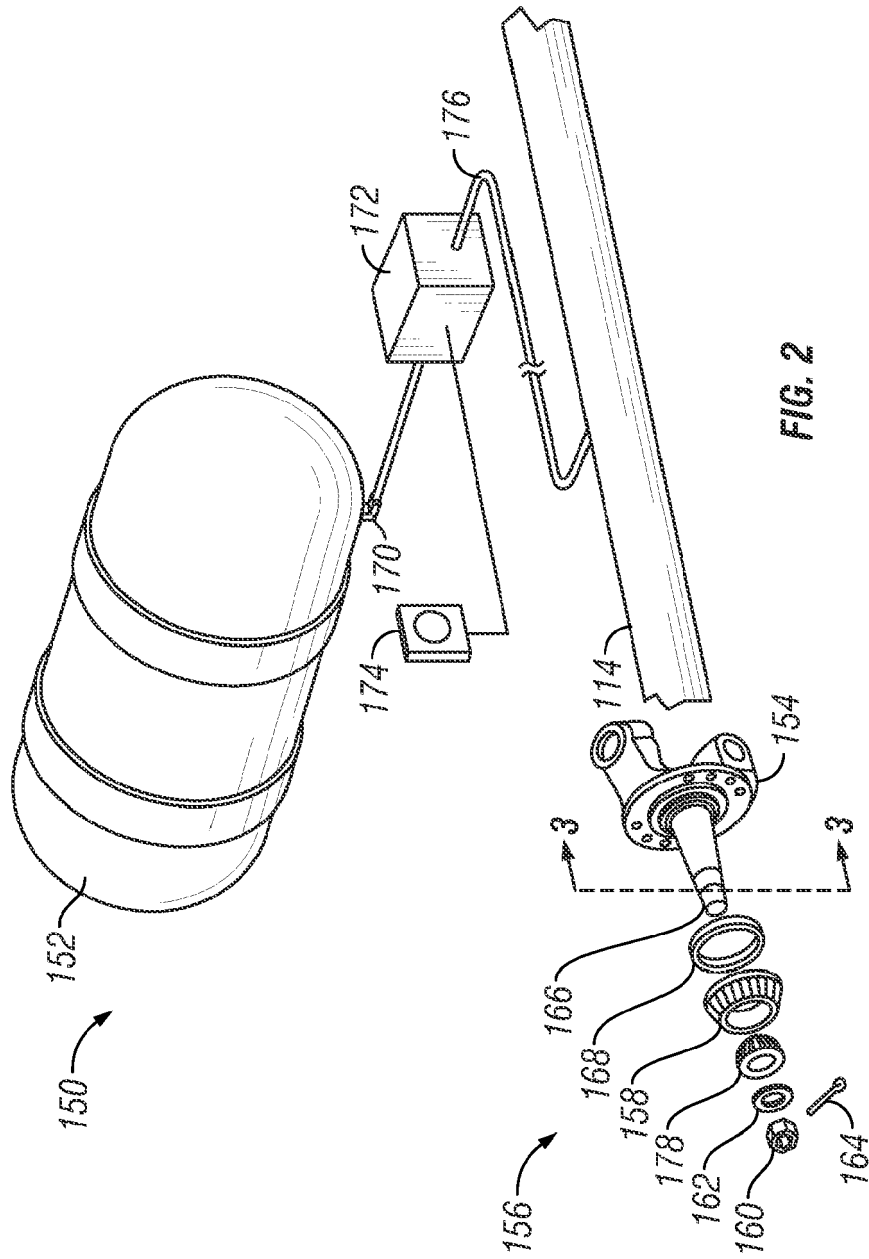


FIG. 2

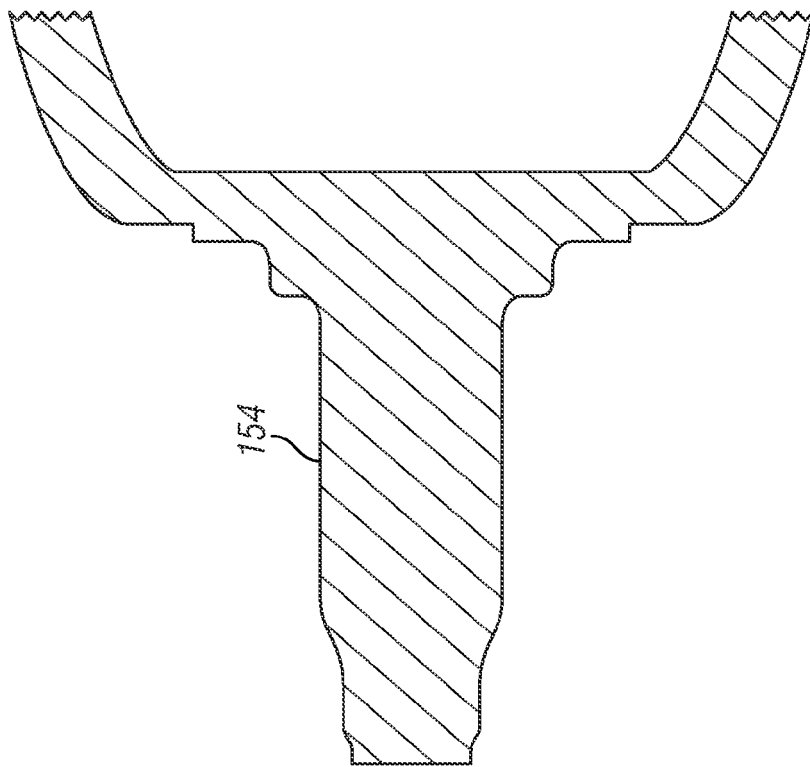


FIG. 3

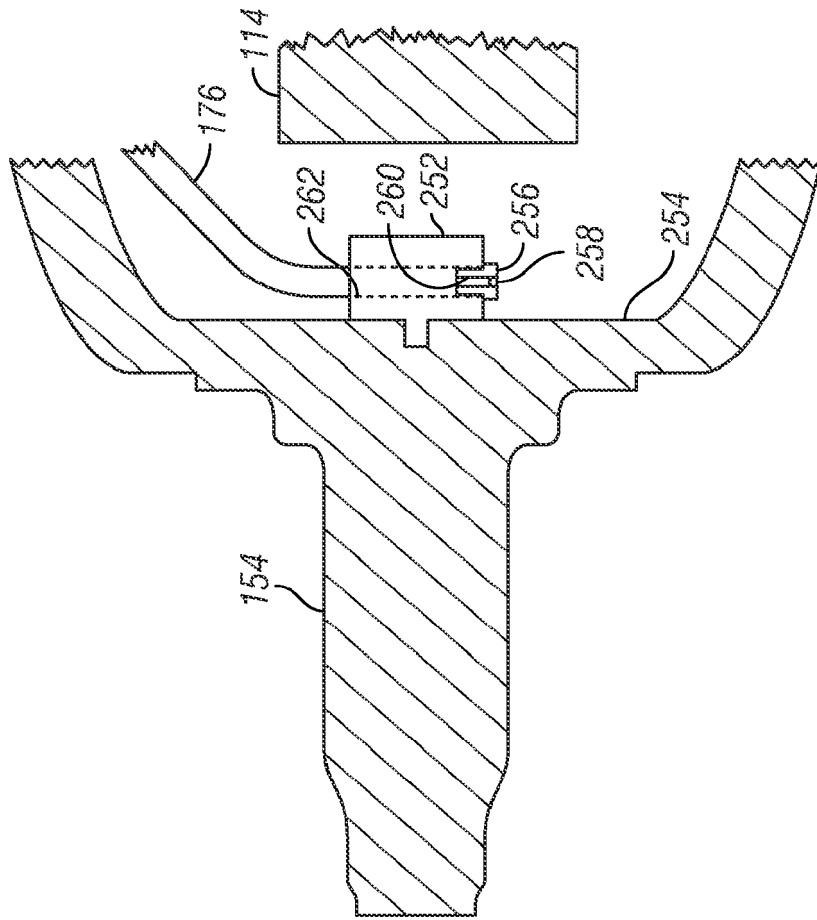


FIG. 4

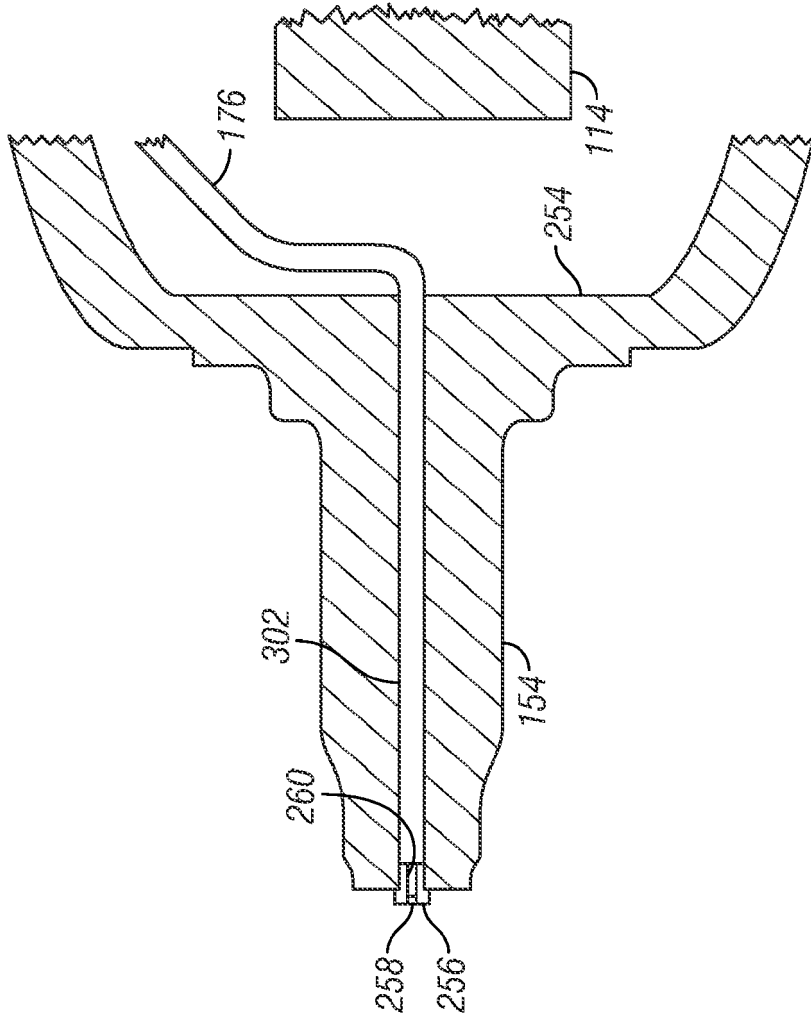


FIG. 5

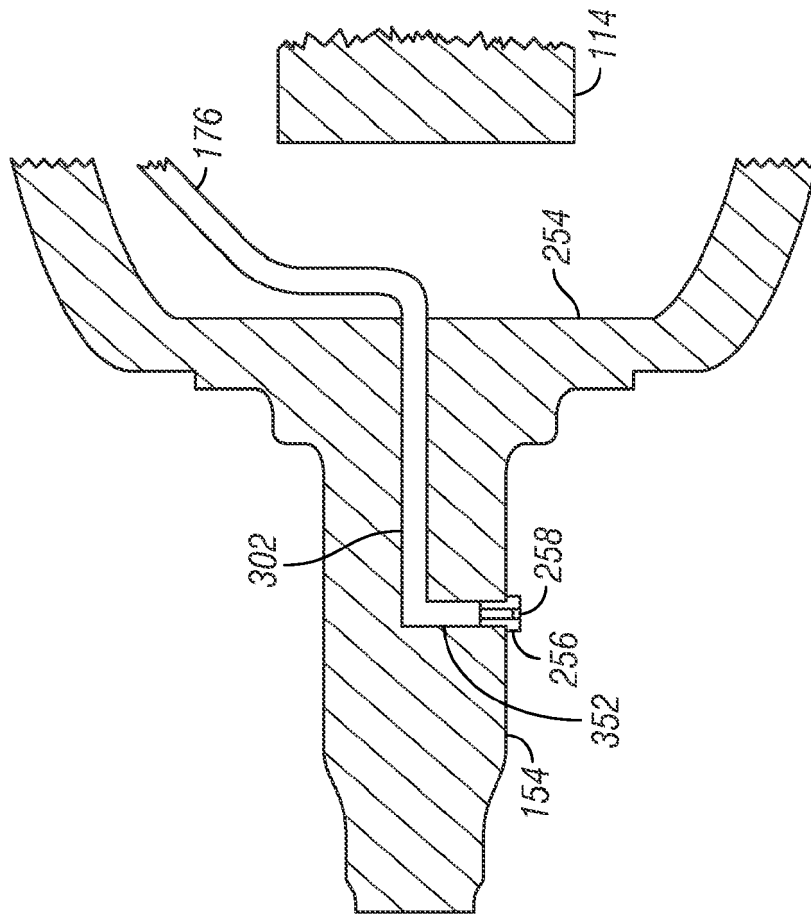
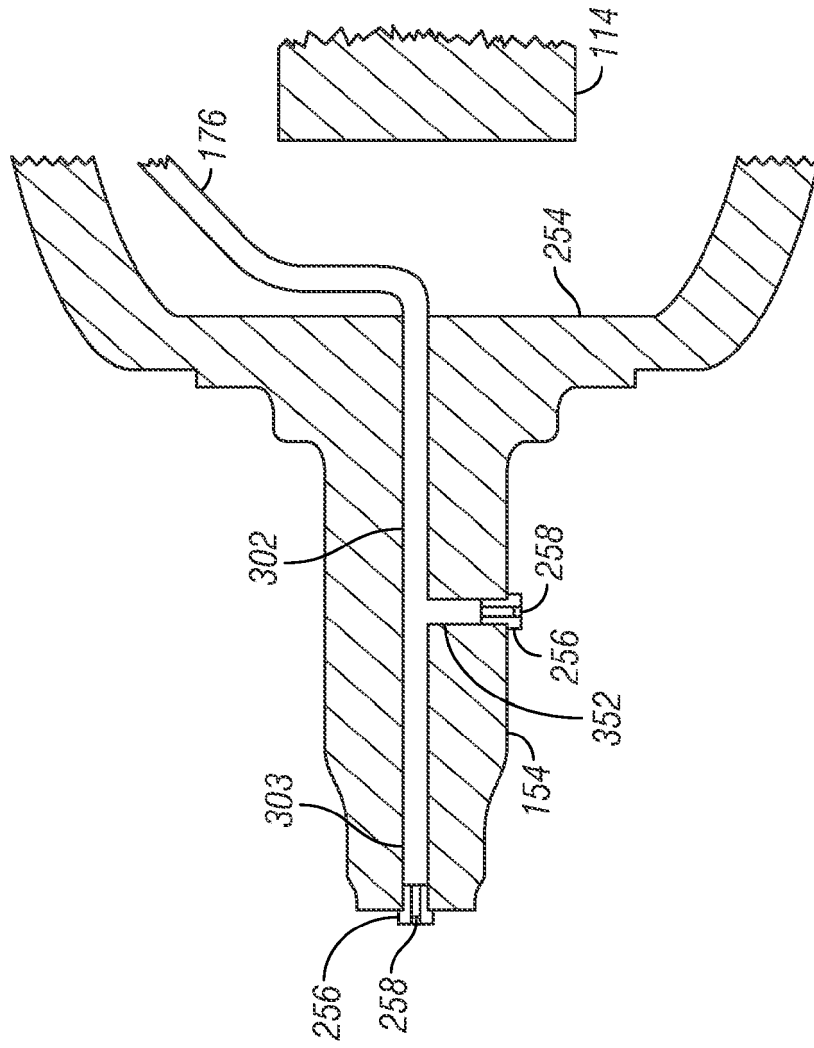


FIG. 6



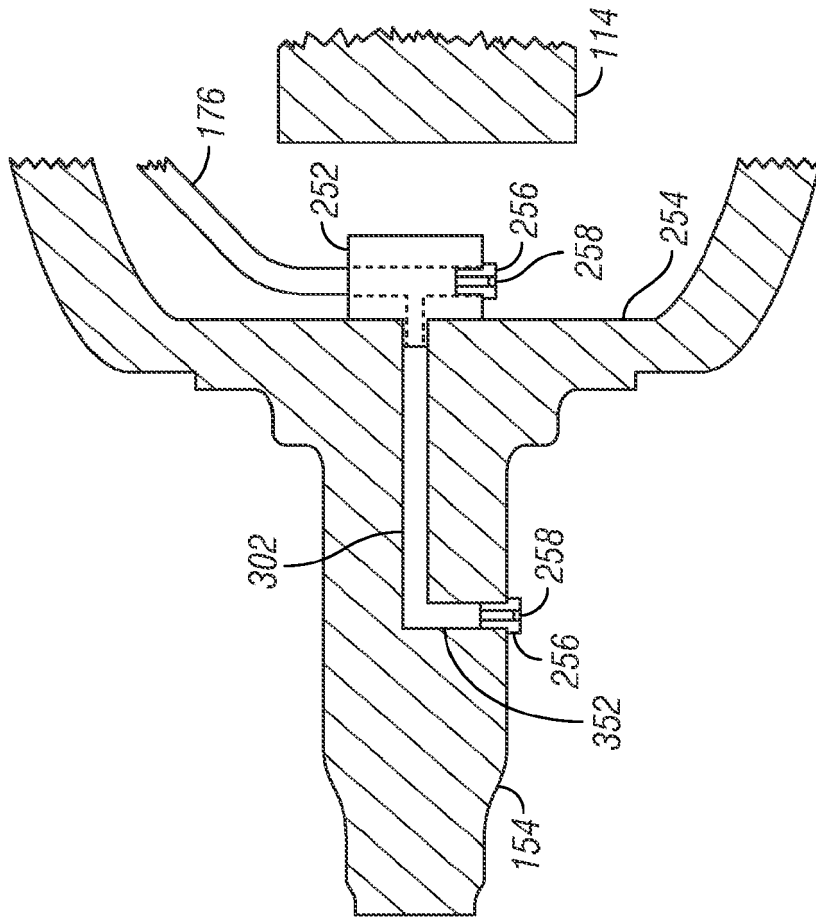


FIG. 9

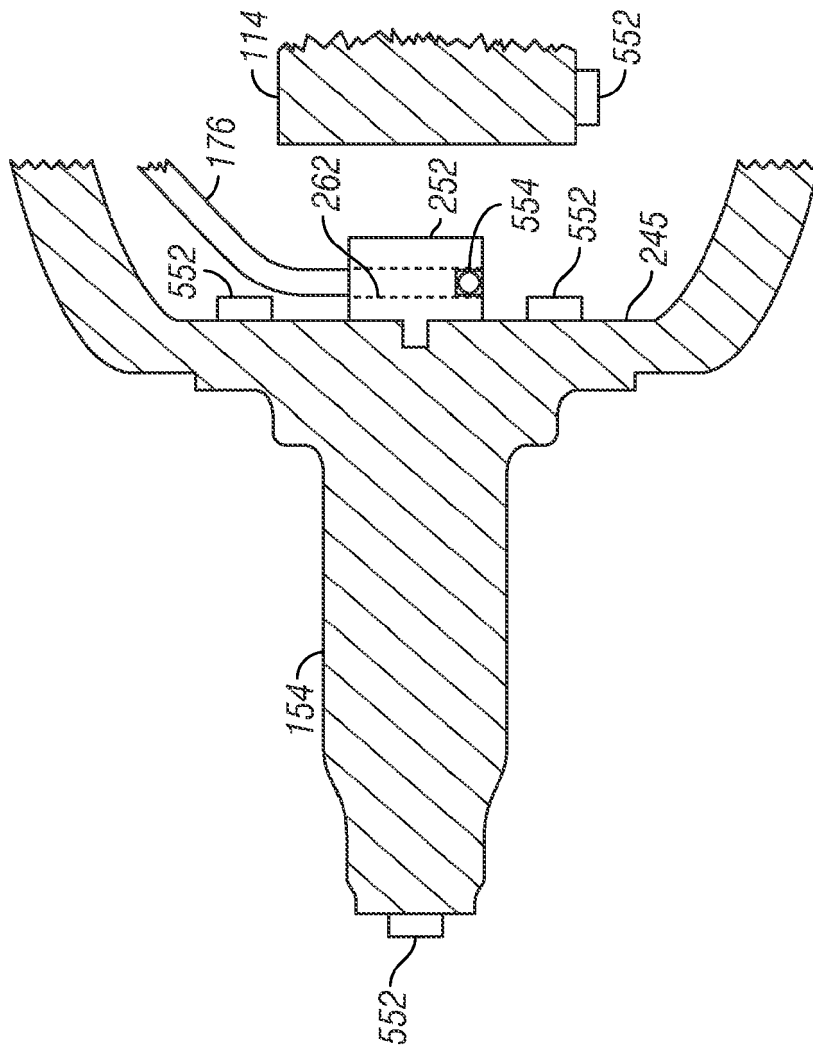
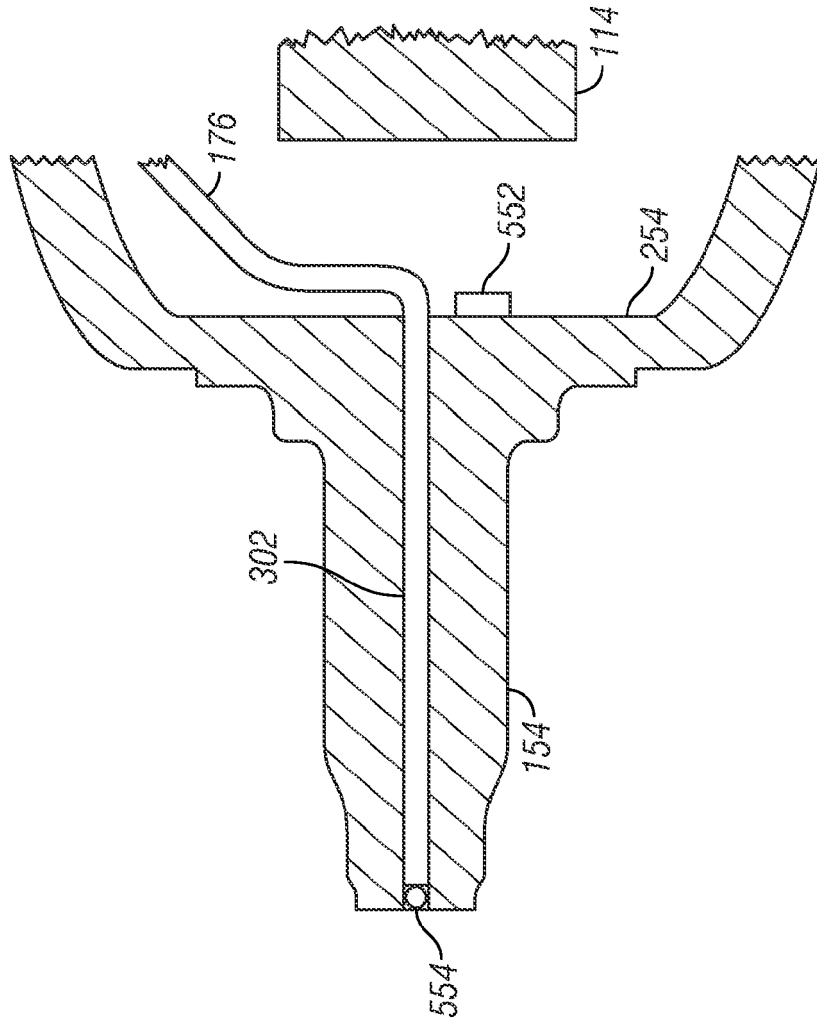


FIG. 10



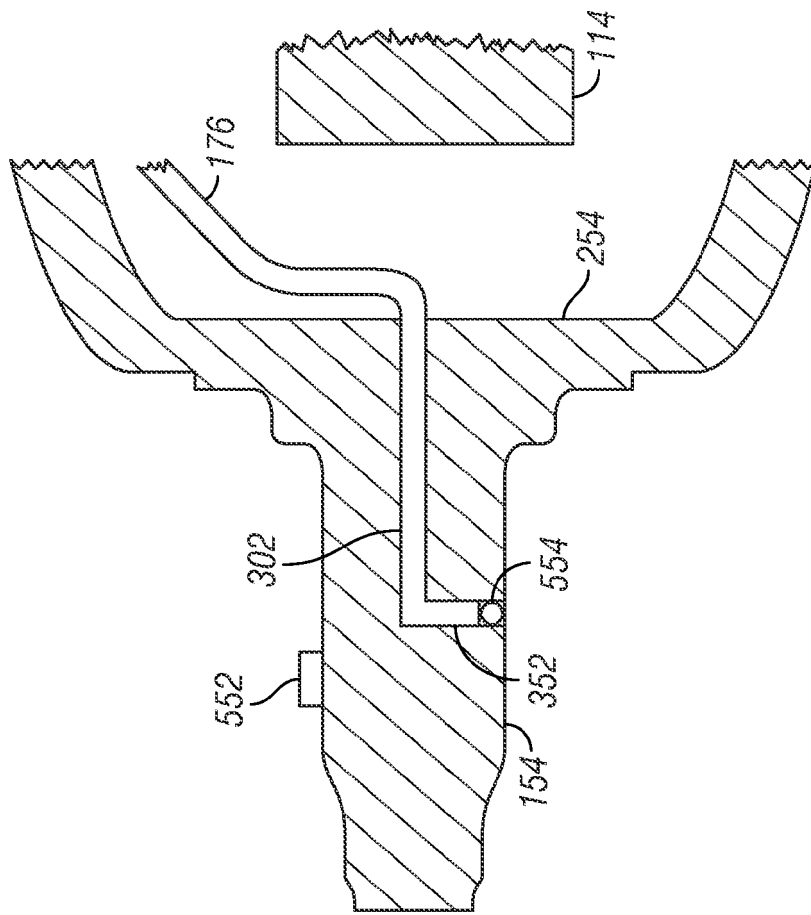


FIG. 12

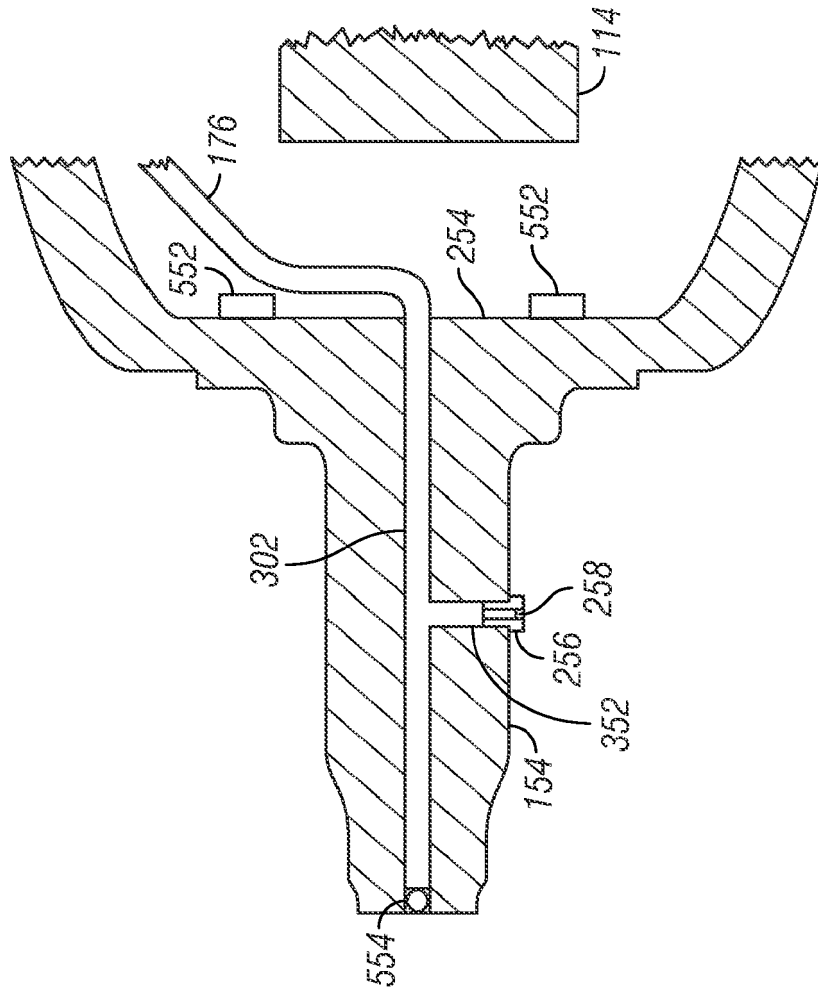


FIG. 13

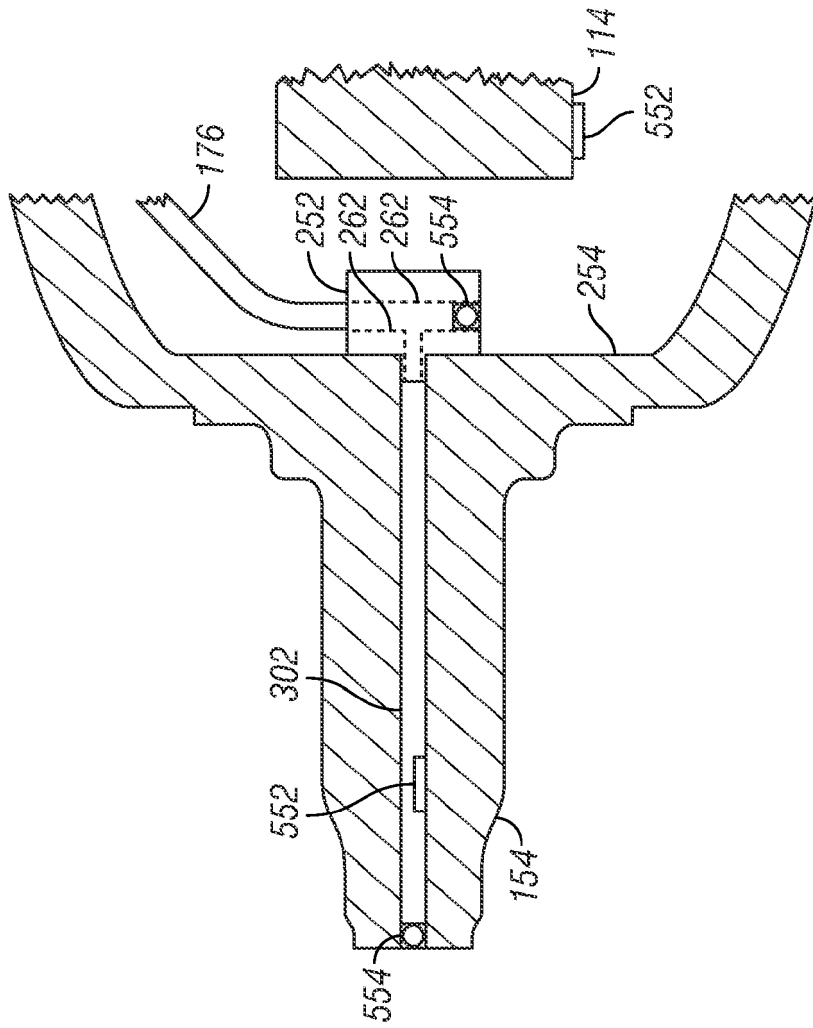


FIG. 14

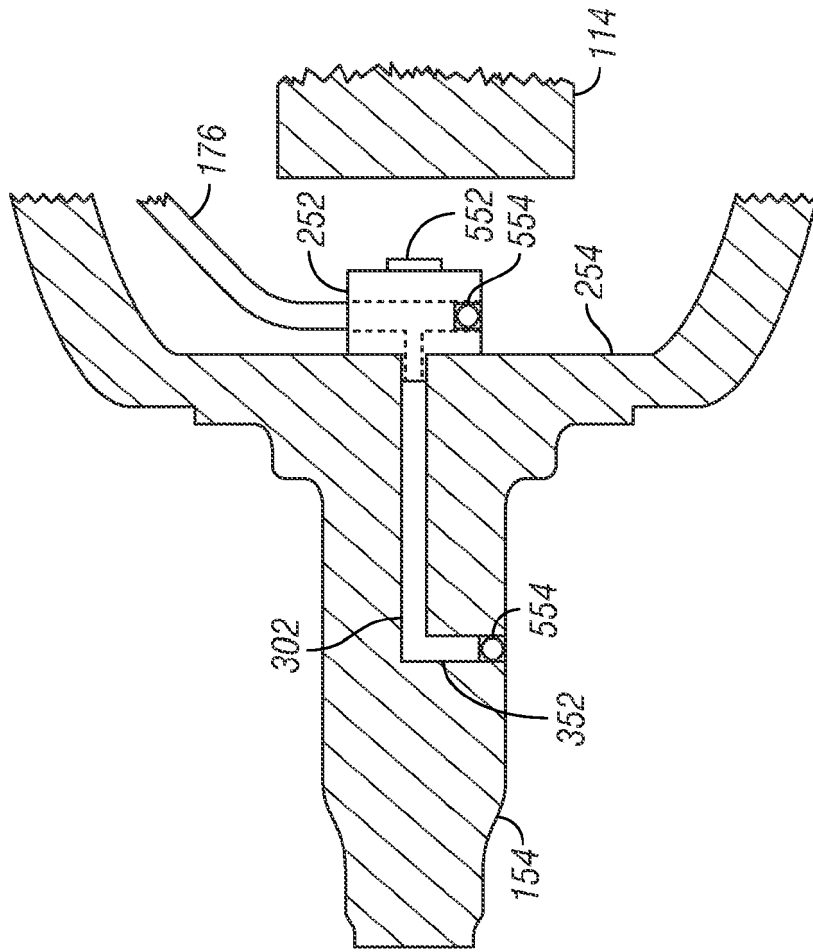
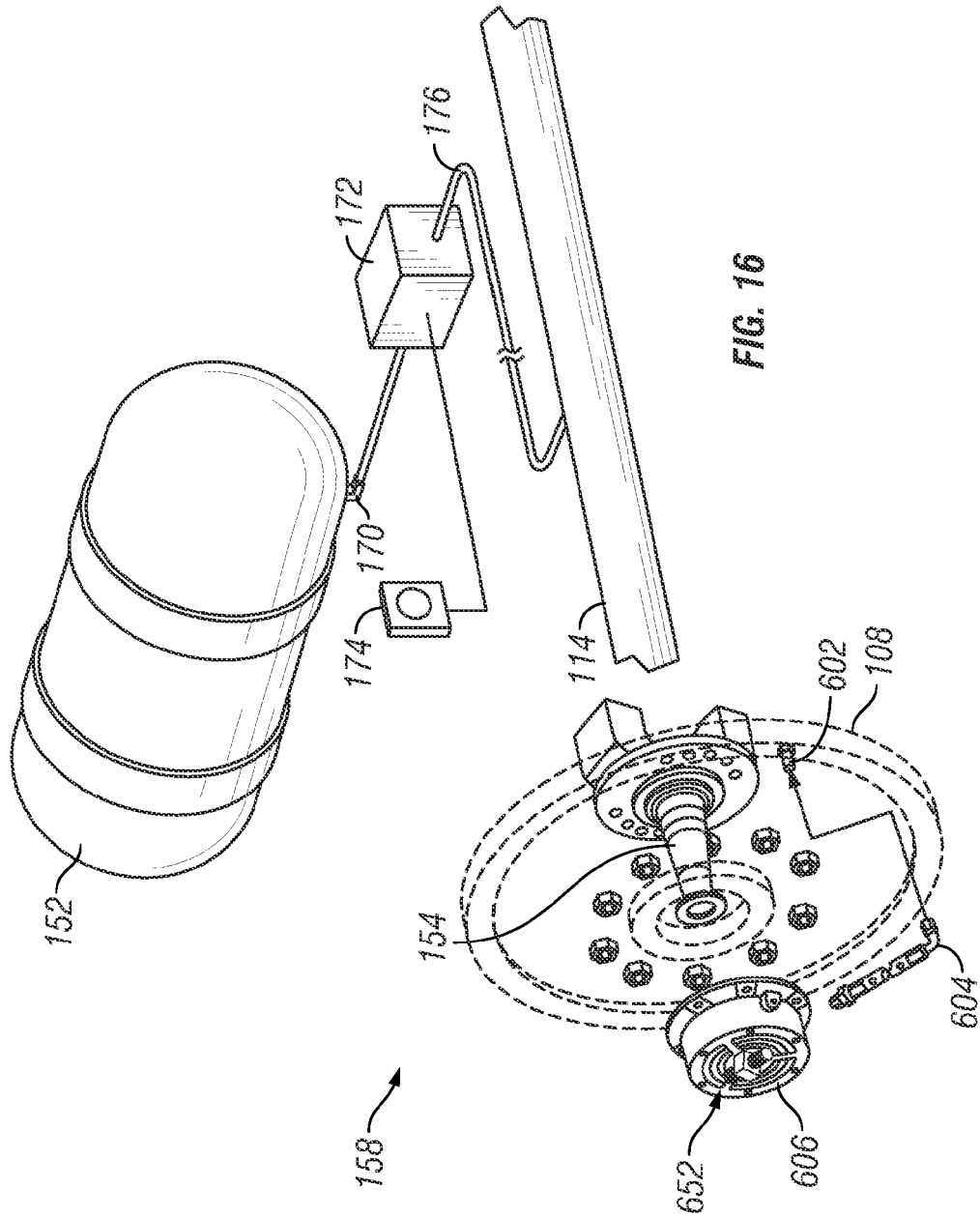


FIG. 15



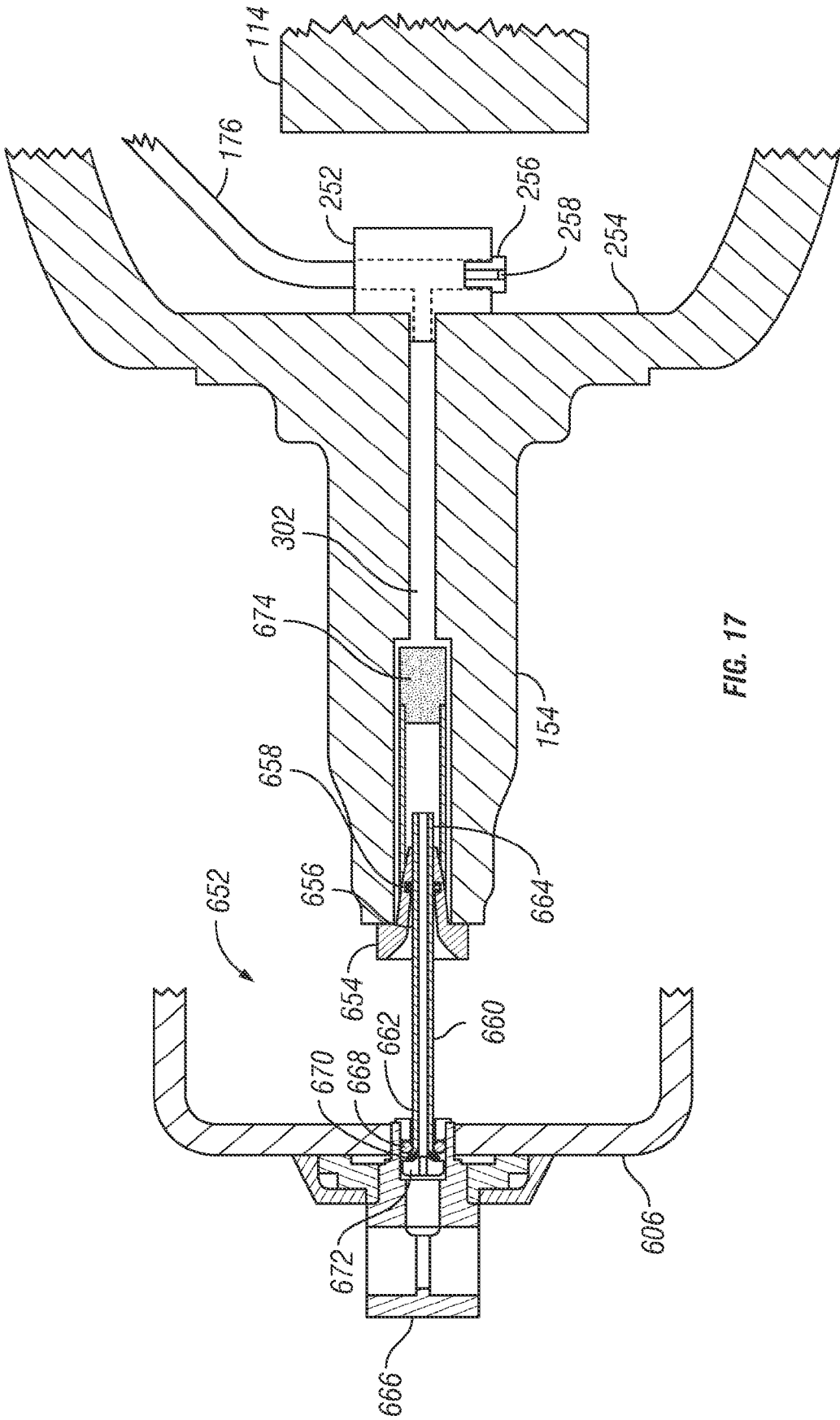
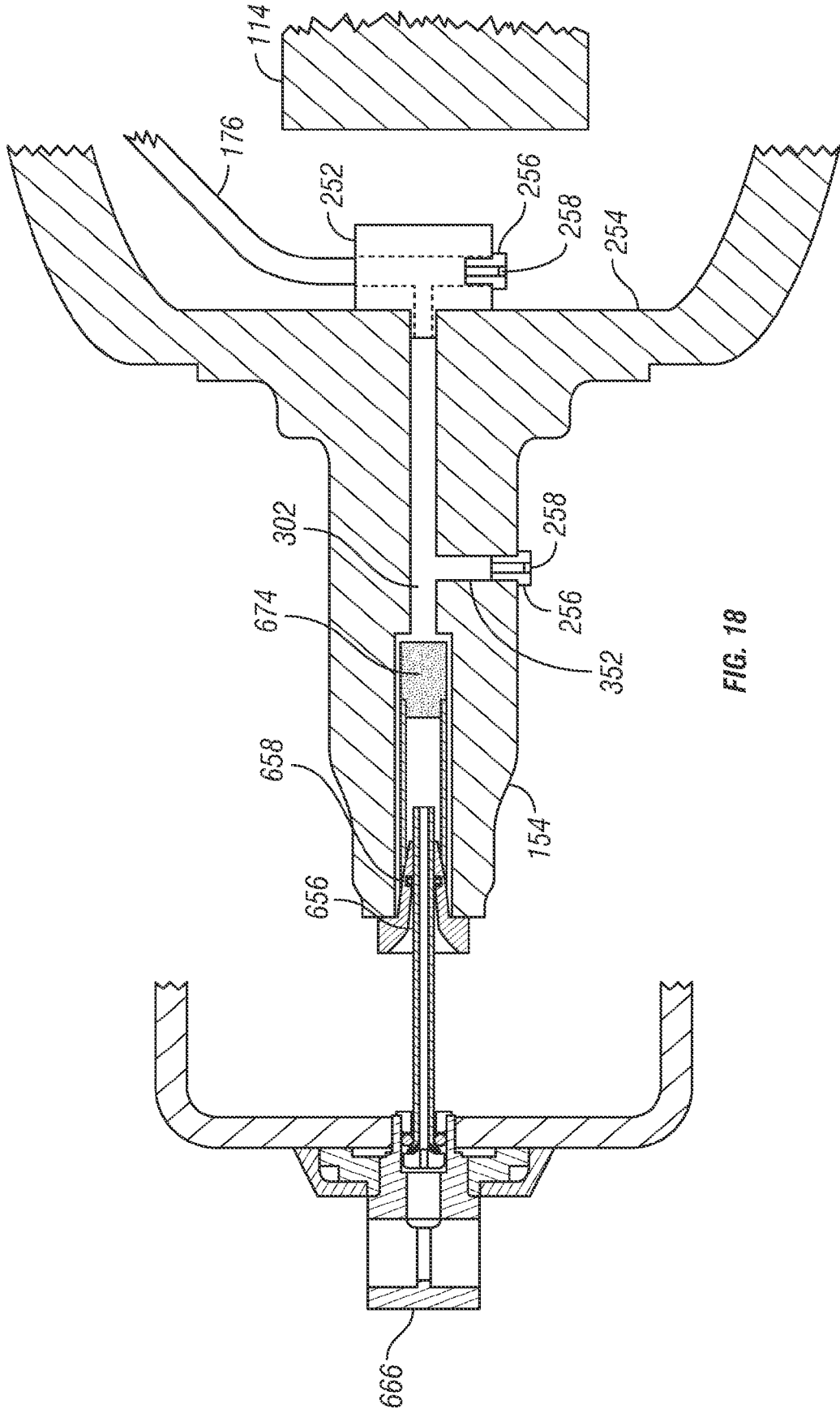
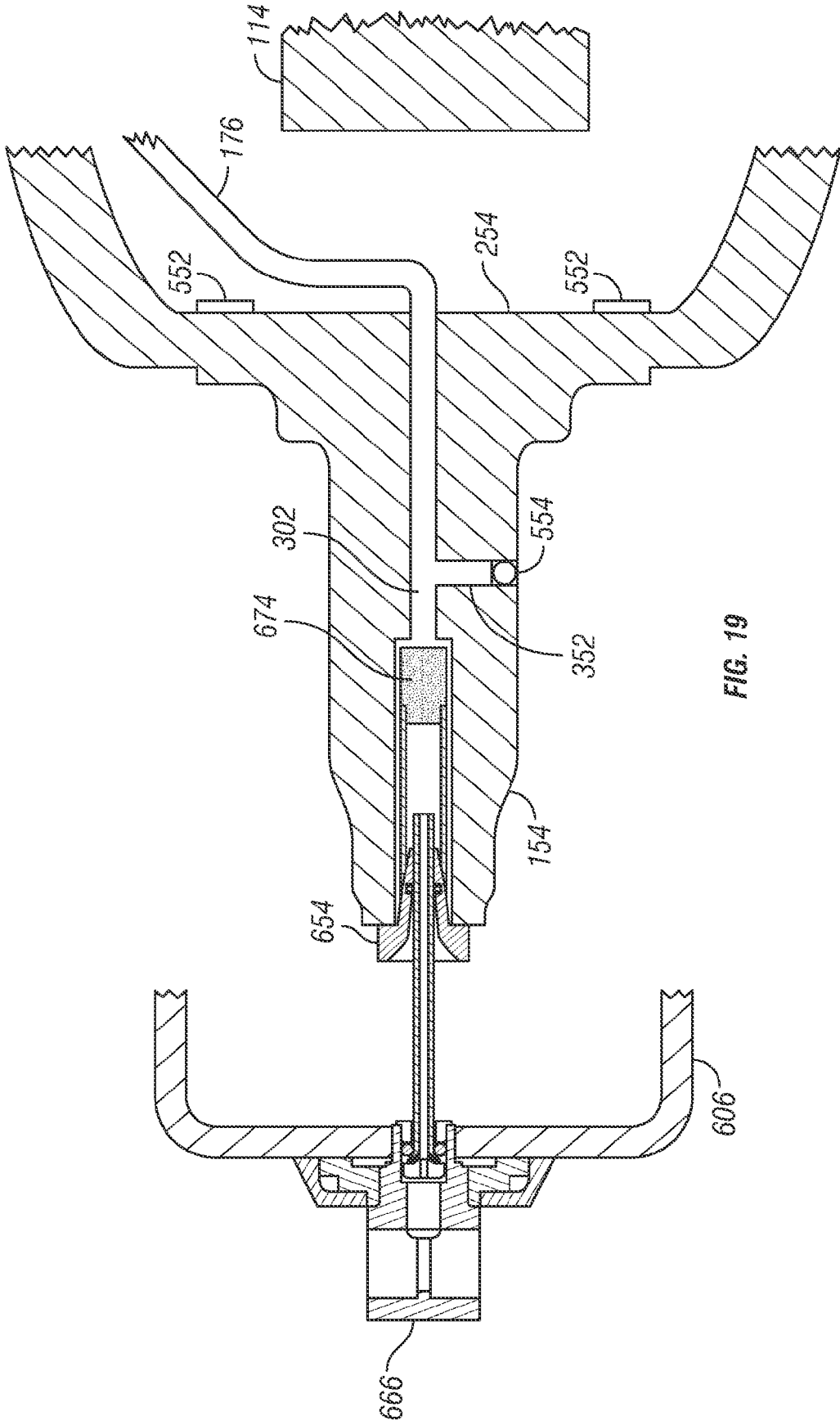


FIG. 17







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Application Number
EP 16 15 1339

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			B60C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 12 April 2016	Examiner Billen, Karl
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