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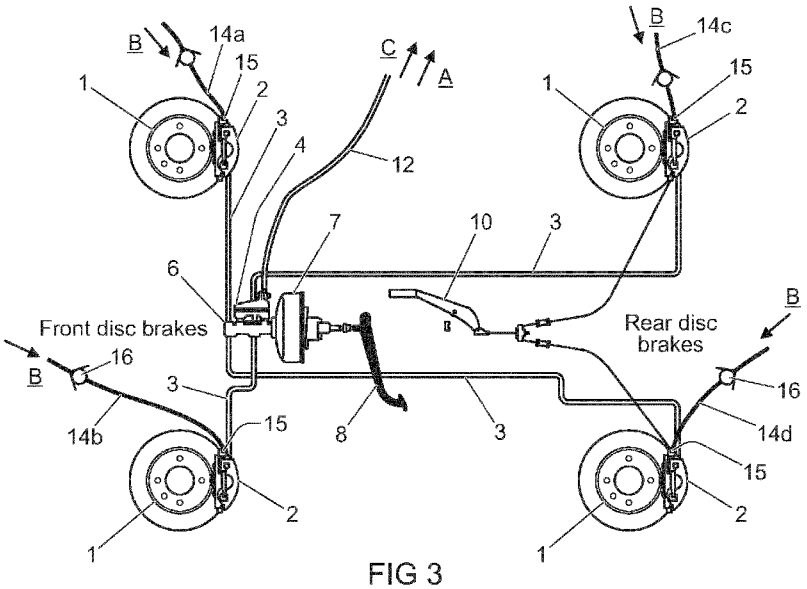

FIG 3

(57) Abstract: A method of filling or refilling a fluid line (3) of a hydraulic fluid system, such as a vehicle braking system, the system having a reservoir source (4) in fluid communication with the fluid line (3) for imparting fluid pressure to an actuator (2) such as a brake caliper or drum, the method comprising the steps of (i) introducing hydraulic fluid into the fluid line at a fluid input port (2) remote from the reservoir source, such as at each brake caliper or drum; and (ii) upon determining that the fluid line (3) is full, ceasing the introduction of the fluid into the fluid line and closing the fluid system.

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IMPROVEMENTS IN AND RELATING TO FILLING METHODS FOR FLUID ACTUATION SYSTEMS

TECHNICAL FIELD

The present invention relates to improvements in and relating to filling methods for fluid actuation systems, particularly but not exclusively to the filling of hydraulic braking systems and, more particularly, to the filling of fluid actuation systems used in a vehicle. The invention further extends to a vehicle comprising a hydraulic braking system.

BACKGROUND

Many fluid actuation systems exist in motor vehicles, such as hydraulic braking systems, power steering, suspension systems and air conditioning units. It is important that such systems are evacuated of air and filled as completely as possible with the system's fluid to ensure their optimum performance.

Automotive brake systems typically consist of disc/drum brakes on each wheel connected by a series of hoses and pipes (herein referred to collectively as a brake line) linking the brake at each wheel to a master cylinder/ hydraulic control unit that is operated by a control typically comprising a foot brake pedal, hand lever or switch. The master cylinder/hydraulic control unit receives hydraulic fluid from a brake fluid reservoir, generally located on top of the master cylinder/control unit. Hydraulic fluid is largely incompressible thus allowing the force applied to the control to be transmitted to the disc/drum brakes as fluid pressure from the master cylinder/hydraulic control unit via the hoses and pipes. The fluid pressure from the master cylinder/hydraulic control unit is applied to the disc brake's caliper piston or drum brake's wheel cylinder which in turn exerts a force on the brake disc or brake drum via a brake pad or a brake shoe respectively.

The type and condition of hydraulic fluid used in the system is critical to ensure safe and consistent operation of the brakes. It is important that there are no air bubbles within the system as, unlike hydraulic fluid, air can compress thus reducing the pressure which the system can attain and creating a spongy feel to the brake pedal and severely limiting the performance and efficiency of the braking system. Thus, the filling, and re-filling, of a hydraulic braking system forms an

important part of the manufacture and maintenance of a vehicle.

The production line for the manufacture of a vehicle conventionally fills the brake system with hydraulic fluid following the removal of air from the system. This is achieved by the application of a vacuum to the system by the connection of a vacuum source to the brake fluid reservoir. A leak measurement system may be present to determine if there is any leakage in the system and a control system manages the process. These measurements are generally made at the reservoir not at the points furthest away, i.e. the brake calipers and these remote points may have a different, and often worse, vacuum level. Once the system is evacuated, brake fluid is pumped into the system through the reservoir (i.e. top down) at a pressure above atmospheric pressure. It is not possible to remove all the air during the evacuation process and as a consequence it remains within the system after filling as air bubbles. As a result, the brake fluid pushes the air to the furthest points of the system; the caliper or drum, corrupting the braking feel.

Generally, re-filling of the brake fluid following production can be achieved by delivering fluid to the brake system via the reservoir, followed by bleeding of the brakes by means of a bleed screw provided on each brake caliper. However, the absorption of moisture by the fluid over time leads to its degradation, and contamination by decomposing brake components results in the need to periodically replace the entire brake fluid within the system. Any air in the system can be removed by bleeding the system, a task that is both time consuming and labour intensive as it often requires a minimum of two personnel; one to bleed the brakes and one to operate the brake pedal. In this respect, a bleed valve is provided on each brake calliper which can be used to bleed the system by connecting a tube to the valve which leads to a container holding the fluid. The brake pedal is pumped a few times to build up pressure in the line and then held down without pumping and the bleed valve loosened to allow brake fluid to flow out to the container, watching for bubbles to exit from the line. Once complete, the valve is tightened and the pedal can then be released. This is repeated until no more bubbles are released into the container and then the process is carried out on each of the other three brake lines. During this procedure, it is also necessary to periodically check the fluid in the reservoir. It is clear that there is significant room for error and that the process is a lengthy one.

It is an object of the present invention to provide an improved process for the initial filling of an actuating fluid in an actuation line for a vehicle that aims to overcome, or at least alleviate, at least

one of the aforementioned drawbacks.

A further object of the present invention is to provide an improved process for the replacement of an actuating fluid in a vehicle actuation system line that aims to overcome, or at least alleviate, at least one of the aforementioned drawbacks.

SUMMARY OF THE INVENTION

Accordingly, one aspect of the present invention provides a method of filling or refilling a fluid line of a hydraulic fluid system, the system having a reservoir source in fluid communication with the fluid line for imparting fluid pressure to an actuator, the method comprising the steps of: (i) introducing hydraulic fluid into the fluid line at a fluid input port remote from the reservoir source; and (ii) upon determining that the hydraulic fluid system is full, ceasing introducing fluid into the fluid line and closing the fluid system.

Thus, the present invention relies on the filling of the system being carried out at a point that is remote from the reservoir source. Generally, the reservoir source is at a higher level in the hydraulic fluid system relative to the fluid input port or ports remote from the reservoir source. It is to be appreciated that the fluid filled system may comprise one or multiple fluid lines. For example, a vehicle braking system generally includes four fluid lines connected to the reservoir source.

The method extends to replacing existing hydraulic fluid in the hydraulic fluid system with replacement hydraulic fluid, in which case determining that the hydraulic fluid system is full may comprise detecting the removal of all existing hydraulic fluid from the reservoir source.

In all embodiments, determining that the hydraulic fluid system is full may comprise detecting fluid in the reservoir source.

Whether filling an empty hydraulic fluid system or refilling a system containing old hydraulic fluid, the fluid line may be evacuated at the reservoir source to remove air or old hydraulic fluid from the system prior to introducing hydraulic fluid into the fluid line. In such embodiments, the method may comprise measuring the pressure within the system and commencing the introduction of hydraulic fluid once a predetermined pressure is achieved in the fluid line. This beneficially ensures that a

sufficient quantity of air or old hydraulic fluid has been removed before supplying new fluid. The method may comprise sucking the hydraulic fluid into the system by means of a pressure difference created by evacuating the fluid line i.e. by means of a vacuum pump connected to the reservoir source. Alternatively, fluid may be pumped into the fluid input port using external pressure.

The method may further comprise attaching a hose or pipe to the reservoir source for evacuation of the fluid filled system.

Preferably, the introduction of fluid into the fluid line of the system is at an input port furthest from the reservoir source. The method of the invention may also comprise connecting a hose or pipe to one or more input ports. Fluid may be introduced into the fluid line at multiple fluid ports remote from the reservoir source, being carried out simultaneously or sequentially.

In an embodiment of the present invention, the fluid is delivered through the multiple lines to an intermediate, preferably smaller, reservoir prior to delivery to the main reservoir source. Preferably, the fluid is delivered from the intermediate reservoir to the main reservoir source via a single fluid line.

The methods according to the aforementioned aspects of the present invention are particularly applicable to the filling of a hydraulic braking system for a vehicle wherein hydraulic fluid (or brake fluid) is pumped into the fluid line at one or each brake caliper or brake drum. To this end, one embodiment of the invention provides a method of filling a hydraulic fluid braking system having a brake fluid reservoir source in fluid communication with a brake fluid line for imparting fluid pressure to a brake caliper or drum, the method comprising the steps of (i) evacuating the fluid system at the brake fluid reservoir to remove air from the system; (ii) introducing brake fluid into the fluid line at an input port provided on one or each brake caliper or drum; and (iii) upon detection of fluid in the brake fluid reservoir, ceasing the introduction of the fluid into the fluid system and closing the fluid system.

The method may also be used for replacing brake fluid in a braking system in accordance with the aforementioned aspect of the present invention.

The brake fluid reservoir collects excess brake fluid passing through the line from the brake calipers or drums. Upon stopping delivery of the fluid, the brake fluid reservoir is re-sealed by re-attachment of a sealing cap and the input ports on each caliper are sealed, for example, by a sealing cap. Preferably, brake fluid is introduced into each caliper input port simultaneously.

Appropriate monitoring and control mechanisms may be provided for controlling the introduction of fluid through the caliper or drum input ports into the brake fluid line.

The method may further comprise the step of attaching an adapter to each caliper or drum, the adapter having a valve and means for attachment to the caliper and hose, wherein the brake fluid is introduced into the caliper via the hose and adapter.

In another aspect of the invention a bleed valve for a hydraulic fluid system is provided. The bleed valve comprises a first fluid channel providing fluid communication between a first inlet and a first outlet, the first fluid channel comprising a non-return valve arranged to deny fluid flow from the first outlet to the first inlet, and a second fluid channel providing fluid communication between a second inlet and a second outlet. The bleed valve further comprises an attachment portion arranged to receive a hose or pipe, wherein the first and second inlets are located on the attachment portion so as to receive fluid from the hose or pipe when the hose or pipe is attached to the attachment portion, and a seating portion arranged to engage with a valve seat, wherein the seating portion is disposed between the first and second outlets.

The first and second fluid channels provide two alternative flow paths for fluid through the valve. The non-return valve determines the direction of flow in the first flow path, while the arrangement of the first and second outlets with respect to the sealing portion determines whether fluid can reach the second outlet when the valve is seated. Therefore, this bleed valve arrangement beneficially allows flow in one direction only when the valve is seated, namely through the first flow path, provided appropriate external seals are included in a valve chamber in which the valve is installed, for example a bleed port, to prevent flow through the second fluid channel to low pressure. This means that fluid can flow from the first inlet to the first outlet, for example for refilling of the hydraulic fluid system, while return flow to the first inlet is prevented by the non-return valve, thereby avoiding leakage. To bleed the hydraulic system, the bleed valve needs to be unseated to allow flow to the second fluid channel.

A particular benefit of this is that, in its use as a bleed valve where it would be installed into a bleed port of a hydraulic system for example, a hose can be attached to the valve to refill the hydraulic system through the first fluid channel without having to unseat the valve. Therefore, the valve only need be unseated when bleeding is required.

The invention also extends to a brake caliper or brake drum comprising the bleed valve of the aforementioned aspect.

In the above described method of the invention, the hydraulic fluid system may comprise a bleed valve, a brake caliper or brake drum of the invention, in which case the method comprises introducing hydraulic fluid through the bleed valve into the fluid line. The seating portion of the bleed valve may be engaged with a valve seat while fluid is introduced into the fluid line. This is a particularly beneficial arrangement which demonstrates a synergy between the method and the bleed valve of the invention, in that, as the method does not require initial bleeding of the hydraulic system, the method can take advantage of the fact that the bleed valve accommodates filling of the hydraulic system while the valve is seated, thereby providing a simpler refilling procedure that finds particular benefit in production environments.

According to another aspect of the invention, there is provided a vehicle comprising a hydraulic braking system having a reservoir source for brake fluid in communication with a brake fluid line for imparting fluid pressure to a brake caliper or drum, wherein the brake caliper or drum is provided with an inlet port having an associated inlet valve to permit the brake fluid line to be filled with fluid through the brake caliper or drum.

The vehicle may comprise a plurality of brake calipers or drums, wherein each of the brake calipers or drums is provided with an inlet port having an associated inlet valve to permit brake fluid to be provided to the brake fluid line via the respective brake caliper or drum.

The brake caliper or drum may be provided with a double port arrangement including the inlet port for brake fluid and a bleed port for bleeding of the brake caliper or drum.

Within the scope of this application it is expressly intended that the various aspects, embodiments,

examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. Features described in connection with one embodiment are applicable to all embodiments, unless such features are incompatible.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention and to show more clearly how it may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings in which:

Figure 1 is a schematic diagram of a vehicle to which embodiments of the invention may be applied;

Figure 2 is a schematic diagram of a conventional vehicle brake fluid filling system;

Figure 3 is a schematic diagram of a vehicle brake fluid filling system for carrying out a process according to one embodiment of the present invention;

Figure 4 is a schematic diagram of a vehicle brake fluid filling system for carrying out a process according to another embodiment of the present invention;

Figure 5 is a flow diagram illustrating the method according to one embodiment of the present invention;

Figure 6 is a flow diagram illustrating the method according to another embodiment of the present invention; and

Figures 7 to 9 show three different bleed valves for use in controlling filling and bleeding of the brake fluid filling systems in Figure 3 and Figure 4.

DETAILED DESCRIPTION

Figure 1 of the accompanying drawings illustrates a vehicle 5 having wheels 9 carrying a set of brakes, the vehicle 5 further including a conventional brake fluid filling system according to the prior art.

Referring to Figure 2, each wheel 9 of the vehicle 5 is provided with a disc or drum brake 1 having a brake caliper or drum wheel cylinder 2 with cylinder that is in fluid communication with the brake fluid reservoir 4, which acts as a reservoir fluid source, via multiple brake lines 3. The reservoir is connected to a master cylinder or hydraulic control unit 6, a vacuum booster 7 and brake pedal 8. The rear brakes are also connected to a mechanical or electric parking brake 10. The fluid lines are normally split into two separate and independent systems (diagonally or front/rear split) so that failure of one system will not result in complete brake loss but to simplify matters the hydraulic system is described as if it was a single system in the accompanying drawings. During manufacture of the vehicle 5 on the production line, a machine (not shown) is employed to remove air from a dry brake system in the direction of arrow A, by means of a vacuum pump connected to the system reservoir 4 by a pipe 12. When a target pressure defining a vacuum level is reached within the line 3, brake fluid is then pumped into the system using the same pipe 12 and system connection, as indicated by arrow B in Figure 2.

The aforementioned process is satisfactory for purpose but not ideal in that air remaining in the system/fluid line is pushed into the far corners of the system, causing air bubbles to develop in the brake fluid line. Furthermore, replenishment of the system has to be carried out by topping up the fluid from the reservoir 4 and then bleeding the line 3 via a bleed port (not shown) provided on each caliper or drum. This requires one person to operate the brake pedal 8 inside the vehicle 5 thereby squeezing out the air trapped in the fluid line and another to tighten and loosen the bleed port. The process also has to be carried out repeatedly and on each of the four calipers or drums.

The present invention provides a new production process and re-filling method that reduces or eliminates air bubbles being formed in the brake line. Referring to Figure 3 of the accompanying drawings, a system adapted for filling a brake system according to one embodiment of the process of the present invention is illustrated. Identical features already described in relation to the system of Figure 2 are given the same reference numerals for the sake of simplicity.

The system is again provided with four brake calipers or drums 2 in communication with a brake

reservoir 4, master cylinder or hydraulic control unit 6, vacuum booster 7 and brake pedal 8 via fluid lines 3. Pipe 12 is provided for evacuating the system on the production line by means of a vacuum pump connected to the pipe 12, as previously discussed in relation to Figure 2 and as indicated by arrow A. However, in addition, four separate pipes 14a, 14b, 14c, 14d are connectable to a bleed port 15 provided on each caliper or drum, each pipe having a valve 16, for example built into a bleed screw. Alternatively or in addition, the bleed valve 16 may be fitted into the bleed port 15, as described later with reference to Figures 7 to 9.

Once a predetermined vacuum pressure is achieved, fluid is delivered through pipes 14a-14d in the direction of arrow B and passes through the entire system until excess fluid is delivered into the reservoir 4 and is collected via the pipe 12 (arrow C in Figure 3). In this manner, the entire line is filled with fluid and any air remaining in the system is expelled through the reservoir and pipe thereby preventing the formation of any air bubbles in the system ensuring optimum braking performance. Once complete, the pipes 12, 14 are removed and the system sealed by sealing of the reservoir and bleed ports. It is to be appreciated that fluid may be delivered through pipes 14a-14d simultaneously or sequentially, the former having the additional advantage of reducing the time of filling on the production line. In this embodiment, the filling of the four lines is preferably controlled such that the four fluid fronts converge together at or near the reservoir 4, for example by means of a modulator.

The present invention provides a simple yet highly effective process for filling a brake fluid system, or other actuation system, with hydraulic fluid, that significantly reduces and possibly eliminates any air trapped within the system. The process can also be carried out in a matter of minutes enabling its use in large scale vehicle manufacture.

Furthermore, the process is also applicable to the re-filling of the brake system with new brake fluid post production line. Conventional brake flushing machines also top-fill the brake line with hydraulic fluid from the reservoir, again leading to air being trapped at far extremities within the system, reducing the performance of the brakes. Bleeding of the brakes can be carried out but this a time-consuming process. In an embodiment of the present invention, each wheel brake caliper or drum is provided with a valve having a sealing cap that protects the valve when not in use. The cap is removed from the brake fluid reservoir and a quick-fit hose is attached to the valve port of one or each brake caliper or drum. Brake fluid is then pumped into the brake line through the valve

of the brake caliper or drum, i.e. the brake line is reverse-filled, until the old/existing fluid passes into the reservoir and is removed. The hose is then removed and the sealing caps placed back on the brake calipers/drums and brake fluid reservoir. In an alternative embodiment, an adaptor having a valve connectable to a hose may be provided for temporary attachment to each caliper or drum. Again, this process is not only quicker than the conventional process in the art but minimizes any air being trapped within the fluid line. It is to be appreciated that the caliper/drum may be provided with a double nipple or double port arrangement, one for use during manufacture with a valve and another for conventional bleeding of the brakes.

A further embodiment of the present invention is shown in Figure 4, in which an intermediate reservoir 18, which may be smaller than the main reservoir 4, is provided between the brake lines 3 and the main master cylinder reservoir source 4, wherein the four brake lines 3 feed into the intermediate reservoir 18 which then feeds into the main reservoir 4 via a single line 20. In this manner, the four brake lines 3 converge at the intermediate reservoir 18 thereby accommodating any variations within the system from the input port(s) to the reservoir 4. This will ensure that once the master cylinder reservoir 4 is filled, the entire system has been filled with fluid by filling via the intermediate reservoir 18, thus eliminating tolerance variations in the system.

Vehicles 5 may incorporate other types of hydraulic fluid lines for actuation of their component parts, such as power steering. It is to be appreciated that the process of the present invention may be employed for the filling of any such fluid line.

Figure 5 of the accompanying drawings is a flow diagram setting out the steps involved in a process 20 according to one embodiment of the invention for the filling of such a fluid line.

The process 20 begins with evacuating at Step 22 air from a hydraulic fluid line 3, said evacuation being performed via the main reservoir 4 using a vacuum pump. The bleed valve 16, which is positioned at an end of the line 3 that is remote from the reservoir 4, is held closed throughout the evacuation step to facilitate the evacuation process. Once a target pressure is achieved in the fluid line 3, for example when the line reaches a state of partial or total vacuum, the bleed valve 16 is opened at Step 24. This enables hydraulic fluid to be delivered at Step 26 to the fluid line 3, the fluid being drawn in by a pressure difference created by the vacuum pump. Delivery of the hydraulic fluid is continued until excess fluid is observed at Step 28 exiting from the fluid line 3 into

the main reservoir 4.

Since the hydraulic fluid is delivered to the line 3 at a point remote from the reservoir 4, excess fluid entering the reservoir 4 from the line 3 is indicative of the line 3 being full with hydraulic fluid. To ensure that the line 3 is full, fluid delivery continues for a short time after excess fluid is first observed until the excess fluid in the reservoir reaches a predetermined level. At this point, both the bleed valve 16 and the reservoir 4 are closed at Step 30 to seal the fluid line 3 which is now filled. The process 20 is now complete.

It should be appreciated that the process 20 described above could vary to account for differing apparatus. For example, if more than one bleed port 15 is available, then the ports may be used either simultaneously or sequentially for filling as required. Furthermore, multiple fluid lines 3 could be filled simultaneously using this method via a common reservoir 4. Also, hydraulic fluid may be pumping into the line 3 using an external pump, rather than being drawn in by the vacuum pump.

It is noted that the process 20 provides a means for filling a hydraulic fluid line 3 in a manner that minimises trapped air primarily by virtue of the fact that fluid is delivered via the bleed port 15, which is remote from and vertically lower than the reservoir 4. This means that air is pushed out of the line into the reservoir 4 as fluid enters.. Alternatively, if a vacuum pump is used to draw the hydraulic fluid into the line 3 this will simultaneously evacuate the line 3 of air.

Such a method could also be extended to the replacement of fluid in the system by the removal of hydraulic fluid from the line prior to its evacuation, and an embodiment of a process 32 for doing so is shown in Figure 6. As the line 3 already contains fluid, there is no need to perform the evacuation step of the above process 20 for filling an empty line. Therefore, the process 32 begins with opening at Step 34 the bleed port 15 and the reservoir 4, and delivering at Step 36 new hydraulic fluid into the line. Old fluid is then observed at Step 38 exiting into the reservoir as it is displaced by new fluid entering the line 3. The volume of fluid contained in the line 3 is known; therefore, once this known volume of fluid has exited the line 3 into the reservoir 4, all of the old fluid has been flushed from the line 3. The line 3 is now full with new fluid, at which point the bleed valve 16 and the reservoir 4 are closed at Step 40 to seal the line 3.

Although the process 32 for re-filling a line 3 does not require an initial evacuation step, such a

step can nonetheless be incorporated if desired, for example to ensure that the new hydraulic fluid is kept separate from the old hydraulic fluid.

It is noted that both of the processes 20, 32 described above operate according to the same underlying principle: fluid initially contained in the line 3, be it air or old hydraulic fluid, is evacuated via the reservoir 4, while new hydraulic fluid is delivered via an input port 15 that is remote from the reservoir.

Figures 7 to 9 illustrate three alternative variants of the bleed valve 16 that is used to control filling and bleeding of the brake fluid lines 3. Each figure shows a variant of the bleed valve 16 as installed into an inlet 42 of a body 44 of a brake drum 2 or brake caliper. For clarity, only a portion of the body 44 of the brake drum 2 is shown. The inlet 42 may be, for example, a bleed port 15 as described above.

In each of the illustrated variants, the inlet 42 is defined by a bore including an enlarged diameter portion at the inlet entrance, the enlarged portion defining a valve chamber 46 in which the valve 16 is received. The remainder of the inlet bore forms an inlet channel 48 that feeds the brake drum 2. At the junction between the valve chamber 46 and the inlet channel 48 a planar shoulder 50 extends laterally between a lower edge of the valve chamber 46 and a generally circular opening into the inlet channel 48. The edge of the opening acts as a valve seat 52 against which a generally cylindrical valve body 54 of each variant of the bleed valve 16 seats to form a seal between the valve chamber 46 and the inlet channel 48.

The tubular inner surface of the valve chamber 46 includes a threaded portion 56, and the valve body 54 in each variant is provided with a corresponding external thread 58 such that the valve body 54 can be screwed into and out of the valve chamber 46 to engage and disengage the valve seat 52 to create or break the seal as required. An o-ring 60 may be provided either above or below the threaded portion 56 to prevent egress of fluid from the valve chamber 46 across the thread. Thread sealant may also be applied to enhance sealing of the valve chamber 46.

In each variant, the valve body 54 includes a portion 62 above the external thread 58 which remains exposed when the valve 16 is installed in the valve chamber 46, to which a pipe for filling or bleeding the brake drum can be attached. The exposed portion 62 is provided with one or more

annular flanges 64 to facilitate secure attachment of the pipe. A valve inlet 66 is defined on a planar upper surface of the valve body 54, such that a pipe fitted onto the exposed portion 62 of the valve body 46 communicates with the valve inlet 66.

The details of each variant of the valve 16 shall now be considered individually.

In the first variant, which is shown in Figure 7, the valve body 46 has a central blind bore 68 which extends axially from the valve inlet 66 to a point slightly short of the lower end of the valve body 46 that engages with the valve seat 52. Below the external thread 58 of the valve body 46, orthogonal cross drillings 70 extend radially inwards to meet the central bore 68 at its lower end to form a junction, which in Figure 7 is shown as t-shaped as only one of the cross drillings 70 is shown; the second cross drilling 70 is represented by a circle at the centre of the junction. This creates a flow path between the valve inlet 66 and the valve chamber 46, such that fluid can flow from the valve inlet 66 to the inlet channel 48 when the valve body 54 is not seated.

Therefore, to open the valve 16 to either bleed or fill the brake drum, the valve body 54 is simply unscrewed to disengage it from the valve seat 52 and open communication between the valve chamber 46 and the inlet channel 48. To close the valve 16, the valve body 54 is screwed in the reverse sense until it re-engages the valve seat 52.

It is noted that the lower end of the valve body 54 is formed with a taper in the Figure 7 variant, which reduces the required manufacturing tolerances for creating an effective seal against the valve seat 52. In other variants, the end of the valve body 54 is planar.

The second variant of the valve 116, shown in Figure 8, has a simple central bore 68 extending entirely through the valve body 54 to provide direct communication between the valve inlet 66 and the inlet channel 48. The exposed portion 62 of the valve body 54 includes a removable cap 72 which accommodates installation of a ball valve 74 into a portion of the central bore 68 in the exposed portion 62 of the valve body 54. The cap 72 screws into the central bore 68 above the ball valve 74 to clamp the ball valve 74 in place. Seals 76 around the edges of the ball valve 74 prevent fluid leakage.

A lever 78 is fitted to a rod 80 that extends laterally away from the ball valve 74. The rod 80 is

rigidly coupled to the ball valve 74, such that rotation of the rod 80 induces rotation of the ball valve 74 about an axis defined by the rod 80. The lever 78 is perpendicular to the rod 80 and external to the body 44 of the brake drum 2, and so enables an operator to twist the rod 80 to rotate the ball valve 74. The lever 78 is removable which advantageously reduces the number of components permanently located in the vehicle 5.

The ball valve 74 has a central hole 82 which, through manipulation of the lever 78 to turn the ball valve 74, can be aligned with the central bore 68 of the valve body 54 to open the valve 116, or moved out of alignment with the central bore 68, thereby breaking communication between the valve inlet 66 and the inlet channel 48 and so closing the valve 16. The ball valve 74 is shown in the open position in Figure 8. Therefore, the variant shown in Figure 8 has the benefit that the valve 16 does not need to be screwed and unscrewed to open and close it, thereby providing easier operation than the variant shown in Figure 7.

Turning finally to Figure 9, in the third variant of the valve 216, which constitutes an embodiment of the invention, a central bore 68 extending fully through the valve body 54 from the valve inlet 66 includes an enlarged portion 84 in which a non-return valve 86 is fitted, held in place by a circlip 88. The non-return valve 86 comprises a ball 90 that is axially biased by a spring 92 against an edge of an opening 94 into the enlarged portion 84, thereby creating a seal that blocks the central bore 68.

Clearly, the non-return valve 86 prevents bleeding of the brake drum 2 through the central bore 68, and so in this embodiment the valve inlet 66 is enlarged and a second bore 96 extends from the valve inlet 66 parallel with the central bore 68. The second bore 96 stops short of the lower end of the valve body 54 where it meets a radial cross drilling 98, thereby providing communication between the valve inlet 66 and the valve chamber 46. When the valve body 54 is seated fluid cannot pass across the seal on the valve seat 52 to reach the second bore 96, and so to bleed the brake drum 2 the valve body 54 must be unscrewed to open communication between the inlet channel 48 and the valve chamber 46, and in turn the second bore 96.

When fluid is delivered into the valve inlet 66 at sufficient pressure, the force exerted on the ball 90 by the fluid pressure is sufficient to overcome the biasing force of the spring 92, and so the ball 90 moves downwardly to open the non-return valve 86 and allow fluid through the central bore 68 and

into the inlet channel 48. Once the pressure drops, the non-return valve 86 closes again to prevent fluid returning to the valve inlet 66. Therefore, conveniently the valve 216 shown in Figure 9 enables filling of the brake drum 2 simply by supplying fluid at sufficient pressure, without having to screw or unscrew the valve body 54, or turn a lever. This makes this embodiment particularly suitable for a production environment.

The valve 216 shown in Figure 9 is particularly suited to use in the above described method of refilling a brake system, as it takes advantage of the fact that the brake system does not require initial bleeding in this method. Therefore, to implement the above described method, a user simply connects a pipe 14a-14d to the valve 216 and pumps brake fluid at an appropriate pressure.

It is noted that the benefits provided by the valve 216 of Figure 9 could not be realised in the conventional approach in which the brake system is bled first, as the valve 216 would have to be unscrewed to allow the initial bleeding; once the valve 216 lifts from the valve seat 52, the non-return valve 86 is ineffective. This applies whether the initial bleeding occurs through the bleed port 15, or through the dedicated pipe 12 shown in Figure 2. In the latter case, the valve 216 must be open to allow air to enter the brake system as brake fluid is removed, to minimise the pumping power required of the vacuum pump.

Therefore, in the conventional refilling method the Figure 9 valve 216 would be used in the same manner as the simpler valve 16 shown in Figure 7, namely unscrewed first to enable bleeding, and so the Figure 9 valve 216 is unnecessarily complicated for that application. However, in the new refilling method described above, the valve 216 shown in Figure 9 provides clear benefits compared with the conventional valve 16 shown in Figure 7. There is therefore a synergy between the refilling method described above and the valve 216 of Figure 9.

It will be appreciated by a person skilled in the art that the invention could be modified to take many alternative forms to that described herein, without departing from the scope of the appended claims.

Further aspects of the invention are set out in the following set of numbered Clauses:

Clause 1. A method of filling or refilling a fluid line of a hydraulic fluid system, the system having a

reservoir source in fluid communication with the fluid line for imparting fluid pressure to an actuator, the method comprising (i) introducing hydraulic fluid into the fluid line at a fluid input port remote from the reservoir source; and (ii) upon determining that the hydraulic fluid system is full, ceasing the introduction of the fluid into the fluid line and closing the fluid system.

Clause 2. A method according to Clause 1, comprising replacing existing hydraulic fluid in the hydraulic fluid system with replacement hydraulic fluid.

Clause 3. A method according to Clause 2, wherein determining that the hydraulic fluid system is full comprises detecting the removal of all existing hydraulic fluid from the reservoir source.

Clause 4. A method according to Clause 1, wherein determining that the hydraulic fluid system is full comprises detecting fluid in the reservoir source.

Clause 5. A method according to Clause 1 comprising controlling and/or monitoring the introduction of fluid through the fluid input ports into the fluid line.

Clause 6. A method according to Clause 1, comprising evacuating the fluid line at the reservoir source to remove air or old hydraulic fluid from the system prior to introducing hydraulic fluid into the fluid line.

Clause 7. A method according to Clause 6, further comprising measuring the pressure within the system and commencing the introduction of the hydraulic fluid once a predetermined pressure is achieved in the fluid line.

Clause 8. A method according to Clause 7, further comprising sucking the hydraulic fluid into the system by means of a pressure difference created by evacuating the fluid line.

Clause 9. A method according to Clause 1, further comprising pumping the hydraulic fluid into the fluid input port using external pressure.

Clause 10. A method according to Clause 1, wherein the fluid input port is at a point furthest from the reservoir source.

Clause 11. A method according to Clause 1, comprising introducing the hydraulic fluid into the fluid line at multiple fluid input ports remote from the reservoir source.

Clause 12. A method according to Clause 11, comprising introducing the hydraulic fluid at the multiple fluid input ports simultaneously.

Clause 13. A method according to Clause 11, comprising introducing the hydraulic fluid at each of the multiple fluid input ports sequentially.

Clause 14. A method according to Clause 1, comprising delivering hydraulic fluid through the fluid line to an intermediate reservoir prior to delivery to the reservoir source.

Clause 15. A method according to Clause 1, wherein the hydraulic fluid system comprises a braking system.

Clause 16. A method according to Clause 1, wherein the hydraulic fluid system is for a vehicle.

Clause 17. A method according to Clause 1, comprising attaching a hose or pipe to the reservoir source and/or the or each fluid input port.

Clause 18. A method according to Clause 1, comprising sealing the reservoir source and/or the or each fluid input port once delivery of the fluid has ceased.

Clause 19. A method according to Clause 1 for filling a hydraulic fluid braking system having a brake fluid reservoir source in fluid communication with a brake fluid line for imparting fluid pressure to a brake caliper or drum, the method comprising (i) evacuating the fluid line at the brake fluid reservoir to remove air from the line; (ii) introducing brake fluid into the fluid line at an input port provided on one or each brake caliper or drum; and (iii) upon detection of fluid in the brake fluid reservoir, ceasing introduction of the fluid into the fluid line and closing the fluid system.

Clause 20. A method according to Clause 2 for replacing existing hydraulic fluid in a hydraulic braking system having a brake fluid reservoir source in fluid communication with a brake fluid line for imparting fluid pressure to a brake caliper or drum, the method comprising (i) introducing replacement brake fluid into the fluid line at an input port provided on one or each brake calliper or

drum; and (ii) upon detection of the replacement fluid in the brake fluid reservoir or upon detection of the removal of all of the existing brake fluid in the brake fluid reservoir, ceasing the introduction of the fluid into the fluid line and closing the fluid system.

Clause 21. A method according to Clause 19, comprising re-sealing of the brake fluid reservoir and the or each input port on each caliper or drum once delivery of the brake fluid has stopped.

Clause 22. A method according to Clause 19, comprising introducing brake fluid into each caliper or drum input port simultaneously.

Clause 23. A bleed valve for a hydraulic fluid system, the bleed valve comprising:

a first fluid channel providing fluid communication between a first inlet and a first outlet, the first fluid channel comprising a non-return valve arranged to deny fluid flow from the first outlet to the first inlet;

a second fluid channel providing fluid communication between a second inlet and a second outlet;

an attachment portion arranged to receive a hose or pipe, wherein the first and second inlets are located on the attachment portion so as to receive fluid from the hose or pipe when the hose or pipe is attached to the attachment portion; and

a seating portion arranged to engage with a valve seat, wherein the seating portion is disposed between the first and second outlets.

Clause 24. A brake caliper or brake drum comprising the bleed valve of Clause 23.

Clause 25. A method according to Clause 1, wherein the hydraulic fluid system comprises a bleed valve comprising a first fluid channel providing fluid communication between a first inlet and a first outlet, the first fluid channel comprising a non-return valve arranged to deny fluid flow from the first outlet to the first inlet, a second fluid channel providing fluid communication between a second inlet and a second outlet, an attachment portion arranged to receive a hose or pipe, wherein the first and second inlets are located on the attachment portion so as to receive fluid from the hose or pipe when the hose or pipe is attached to the attachment portion, and a seating portion arranged to engage with a valve seat, wherein the seating portion is disposed between the first and second outlets. or a brake caliper or brake drum comprising said bleed valve, and wherein the method

comprises introducing hydraulic fluid through said bleed valve into the fluid line.

Clause 26. A method according to Clause 25, wherein the seating portion of the bleed valve is engaged with a valve seat while fluid is introduced into the fluid line.

Clause 27. A vehicle comprising a hydraulic braking system having a reservoir source for brake fluid in communication with a brake fluid line for imparting fluid pressure to a brake caliper or drum, wherein the brake caliper or drum is provided with an inlet port having an associated inlet valve to permit the brake fluid line to be filled with fluid through the brake caliper or drum.

Clause 28. The vehicle according to Clause 27, comprising a plurality of brake calipers or drums, wherein each of the brake calipers or drums is provided with an inlet port having an associated inlet valve to permit brake fluid to be provided to the brake fluid line via the respective brake caliper or drum.

Clause 29. The vehicle according to Clause 27, wherein the brake caliper or drum is provided with a double port arrangement including the inlet port for brake fluid and a bleed port for bleeding of the brake caliper or drum.

CLAIMS

1. A method of filling or refilling a fluid line of a hydraulic fluid system, the system having a reservoir source in fluid communication with the fluid line for imparting fluid pressure to an actuator, the method comprising the steps of: (i) evacuating the fluid line at the reservoir source to remove air or old hydraulic fluid from the system prior to (ii) introducing new hydraulic fluid into the fluid line at a fluid input port remote from the reservoir source; and (iii) upon determining that the fluid line is full, ceasing the introduction of the fluid into the fluid line and closing the fluid system.

2. A method according to claim 1, comprising replacing existing hydraulic fluid in the hydraulic fluid system with replacement hydraulic fluid.

3. A method according to claim 2, wherein determining that the fluid line is full comprises detecting the removal of all existing hydraulic fluid from the reservoir source.

4. A method according to any one of the preceding claims, wherein determining that the fluid line is full comprises detecting fluid in the reservoir source.

5. A method according to any one of the preceding claims comprising controlling and/or monitoring the introduction of fluid through the fluid input port into the fluid line.

6. A method according to any one of the preceding claims comprising measuring the pressure within the system and commencing the introduction of hydraulic fluid once a predetermined pressure is achieved in the fluid line.

7. A method according to claim 6 comprising sucking the hydraulic fluid into the system by means of a pressure difference created by evacuating the fluid line.

8. A method according to any one of the preceding claims comprising pumping the hydraulic fluid into the fluid input port using external pressure.

9. A method according to any one of the preceding claims wherein the fluid input port is at a point furthest from the reservoir source.

10. A method according to any one of the preceding claims comprising introducing the hydraulic fluid into the fluid line at multiple fluid input ports remote from the reservoir source.

11. A method according to claim 10 comprising introducing the fluid at the multiple fluid input ports simultaneously.

12. A method according to claim 10 comprising introducing the fluid at each of the multiple fluid input ports sequentially.

13. A method according to any one of the preceding claims comprising delivering hydraulic fluid through the fluid line to an intermediate reservoir prior to delivery to the reservoir source.

14. A method according to any one of the preceding claims wherein the hydraulic fluid system comprises a braking system.

15. A method according to any one of the preceding claims wherein the hydraulic fluid system is for a vehicle.

16. A method according to any one of the preceding claims comprising attaching a hose or pipe to the reservoir source and/or the or each fluid input port.

17. A method according to any one of the preceding claims comprising sealing the reservoir source and/or the or each fluid input port once delivery of the hydraulic fluid has ceased.

18. A method according to claim 1 for filling a brake fluid line of a hydraulic fluid braking system having a brake fluid reservoir source in fluid communication with the brake fluid line for imparting fluid pressure to a brake caliper or drum, the method comprising the steps of: (i) evacuating the brake fluid line at the brake fluid reservoir to remove air from the line; (ii) introducing brake fluid into the fluid line at an input port provided on one or each brake caliper or drum; and (iii) upon detection of fluid in the brake fluid reservoir, ceasing introduction of the fluid into the fluid line and closing the fluid system.

19. A method according to claim 2 for replacing existing hydraulic fluid in a brake fluid line of a hydraulic braking system having a brake fluid reservoir source in fluid communication with the brake fluid line for imparting fluid pressure to a brake caliper or drum, the method comprising the steps of: (i) introducing replacement brake fluid into the fluid line at an input port provided on one or each brake calliper or drum; and (ii) upon detection of the replacement fluid in the brake fluid reservoir or upon detection of the removal of all of the existing brake fluid in the brake fluid reservoir, ceasing the introduction of the fluid into the fluid line and closing the fluid system.

20. A method according to claim 18 or 19 comprising re-sealing of the brake fluid reservoir and the or each input port on each caliper or drum once delivery of the brake fluid has stopped.

21. A method according to any one of claims 18 to 20 comprising introducing brake fluid into each caliper or drum input port simultaneously.

22. A bleed valve for a hydraulic fluid system, the bleed valve comprising:

a first fluid channel providing fluid communication between a first inlet and a first outlet, the first fluid channel comprising a non-return valve arranged to deny fluid flow from the first outlet to the first inlet;

a second fluid channel providing fluid communication between a second inlet and a second outlet;

an attachment portion arranged to receive a hose or pipe, wherein the first and second inlets are located on the attachment portion so as to receive fluid from the hose or pipe when the hose or pipe is attached to the attachment portion; and

a seating portion arranged to engage with a valve seat, wherein the seating portion is disposed between the first and second outlets.

23. A brake caliper or brake drum comprising the bleed valve of claim 22.

24. A method according to any one of claims 1 to 21, wherein the hydraulic fluid system comprises a bleed valve according to claim 22, or a brake caliper or brake drum according to claim 23, and wherein the method comprises introducing hydraulic fluid through the bleed valve into the fluid line.

25. A method according to claim 24, wherein the seating portion of the bleed valve is engaged with a valve seat while fluid is introduced into the fluid line.

26. A vehicle comprising a hydraulic braking system having a reservoir source for brake fluid in communication with a brake fluid line for imparting fluid pressure to a brake caliper or drum, wherein the brake caliper or drum is provided with an inlet port having an associated inlet valve to permit the brake fluid line to be filled with fluid through the brake caliper or drum.

27. The vehicle according to claim 26, comprising a plurality of brake calipers or drums, wherein each of the brake calipers or drums is provided with an inlet port having an associated inlet valve to permit brake fluid to be provided to the brake fluid line via the respective brake caliper or drum.

28. The vehicle according to claim 26 or claim 27, wherein the brake caliper or drum is provided with a double port arrangement including the inlet port for brake fluid and a bleed port for bleeding of the brake caliper or drum.

29. The vehicle according to claim 27 or claim 28, wherein the inlet valve is a bleed valve according to claim 22.

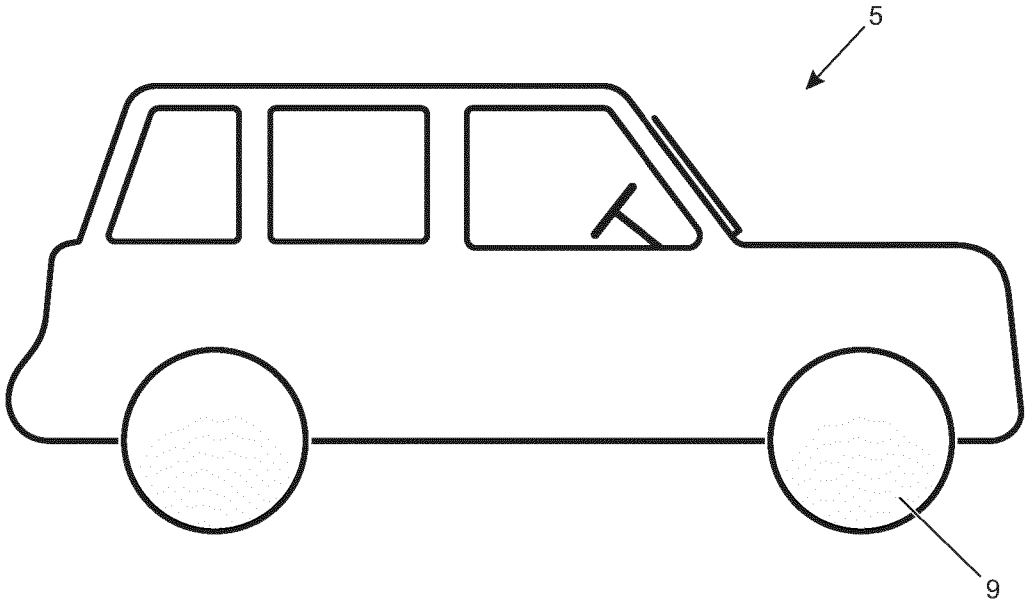
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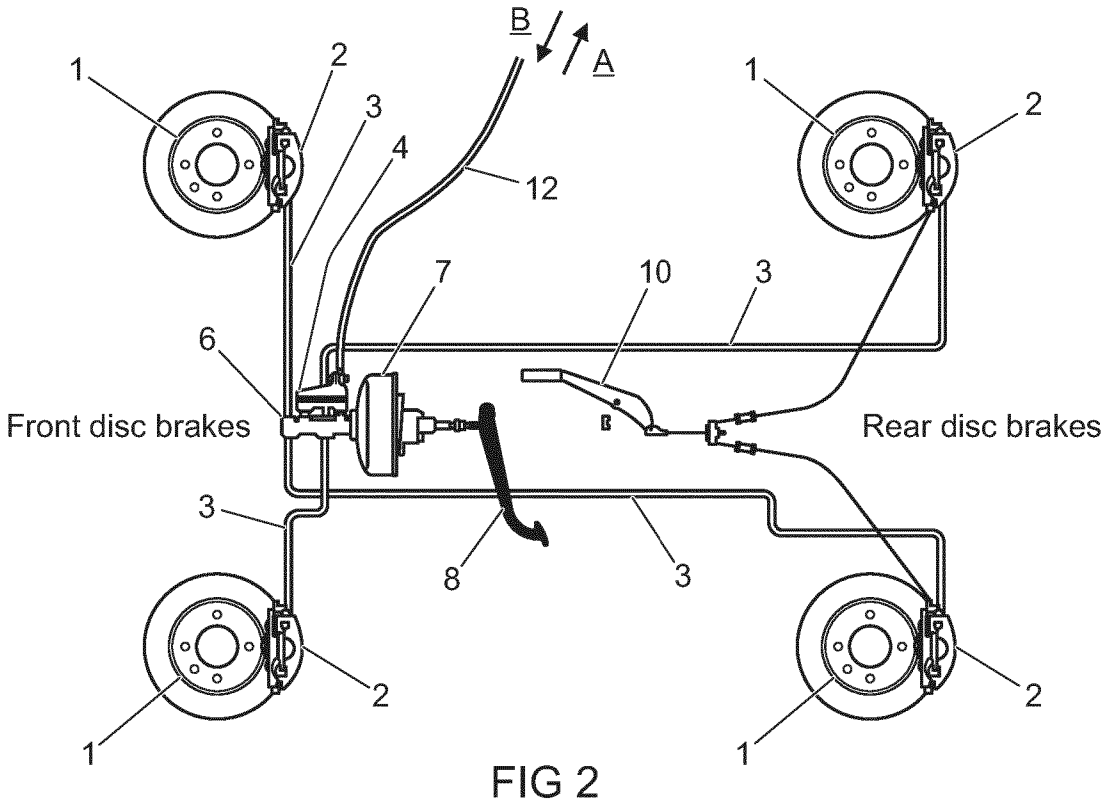
FIG 1


B
A
1
2
3
4
12
7
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6
Front disc brakes
Rear disc brakes
3
8
3
1
2
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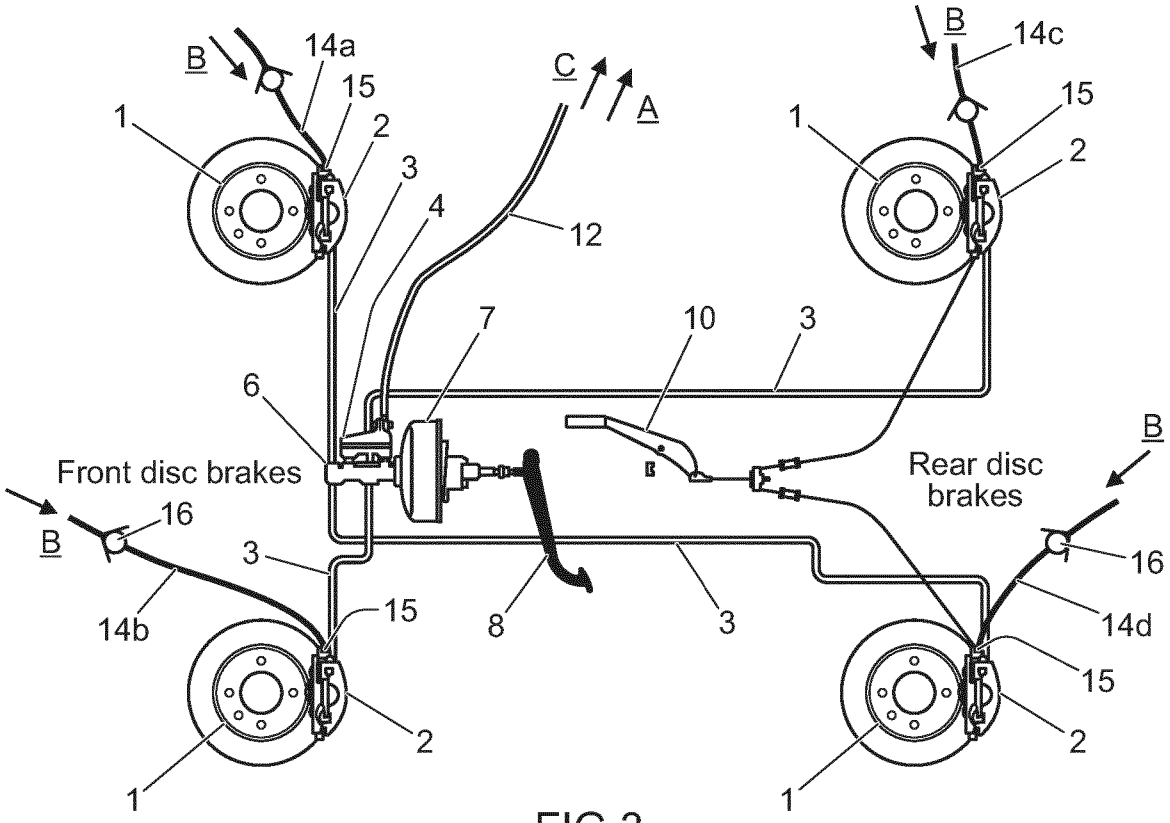
2
1
2

FIG 2


B
14a
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6
Front disc brakes
Rear disc brakes
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16
B
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14b
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8
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14d
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FIG 3

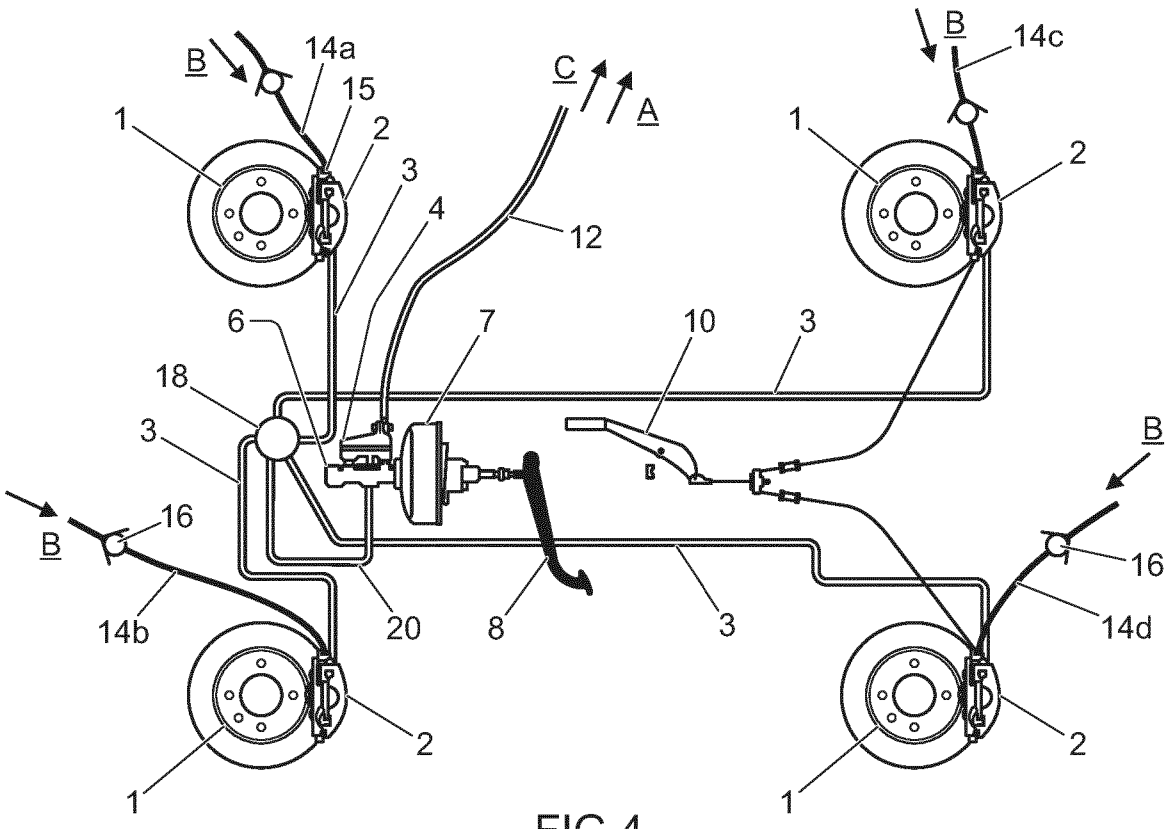
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FIG 4

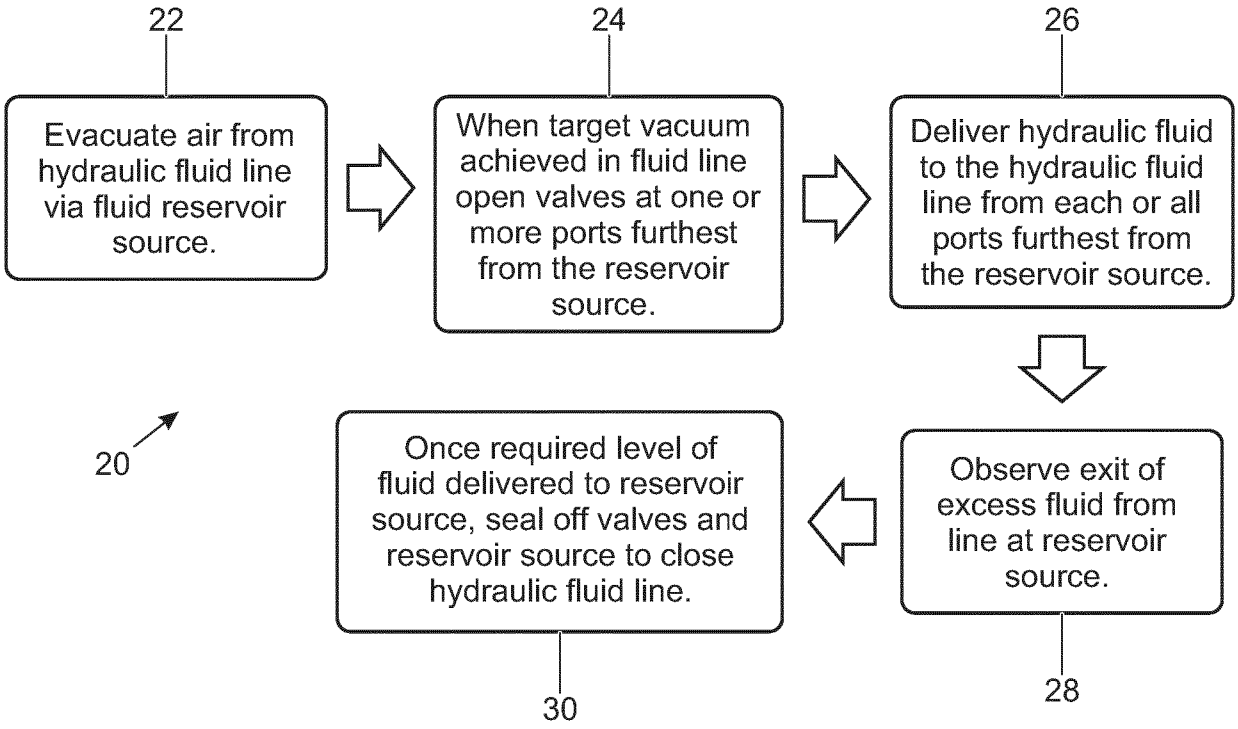
22
Evacuate air from hydraulic fluid line via fluid reservoir source.
24
When target vacuum achieved in fluid line open valves at one or more ports furthest from the reservoir source.
26
Deliver hydraulic fluid to the hydraulic fluid line from each or all ports furthest from the reservoir source.
28
Observe exit of excess fluid from line at reservoir source.
30
Once required level of fluid delivered to reservoir source, seal off valves and reservoir source to close hydraulic fluid line.
20

FIG 5

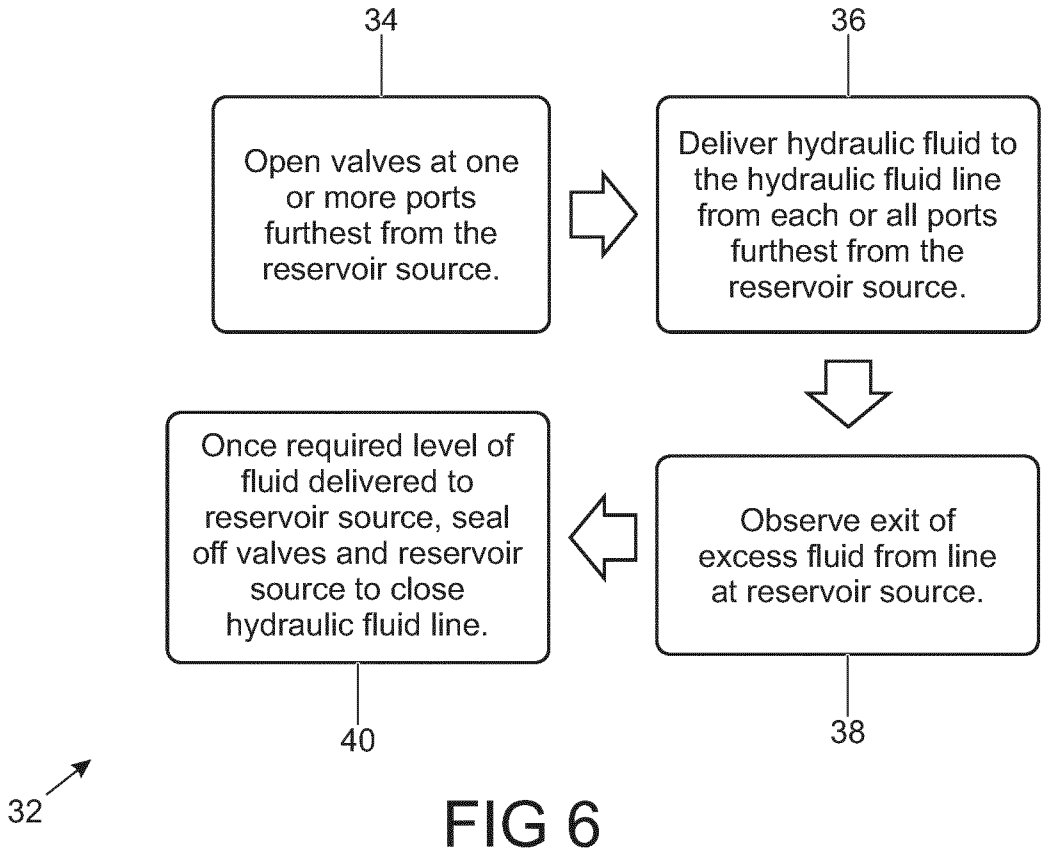
34
Open valves at one or more ports furthest from the reservoir source.
36
Deliver hydraulic fluid to the hydraulic fluid line from each or all ports furthest from the reservoir source.
38
Observe exit of excess fluid from line at reservoir source.
40
Once required level of fluid delivered to reservoir source, seal off valves and reservoir source to close hydraulic fluid line.
32

FIG 6

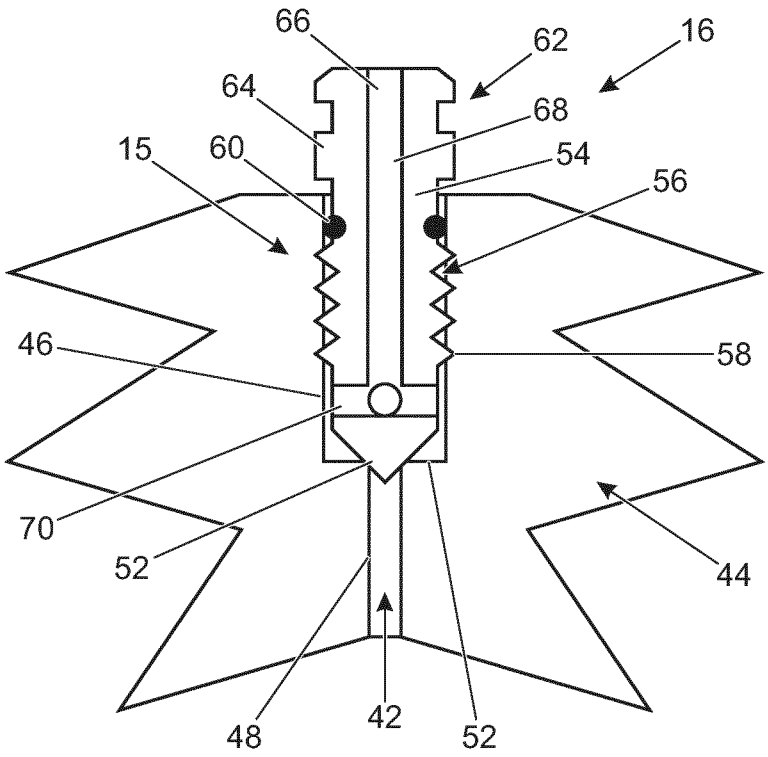
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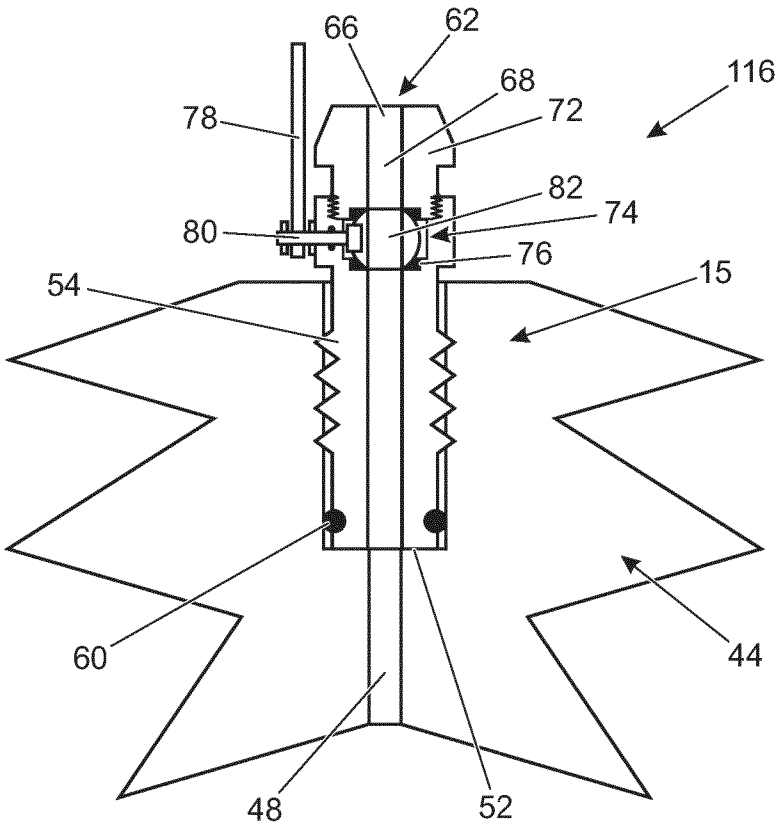
FIG 7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52

FIG 8

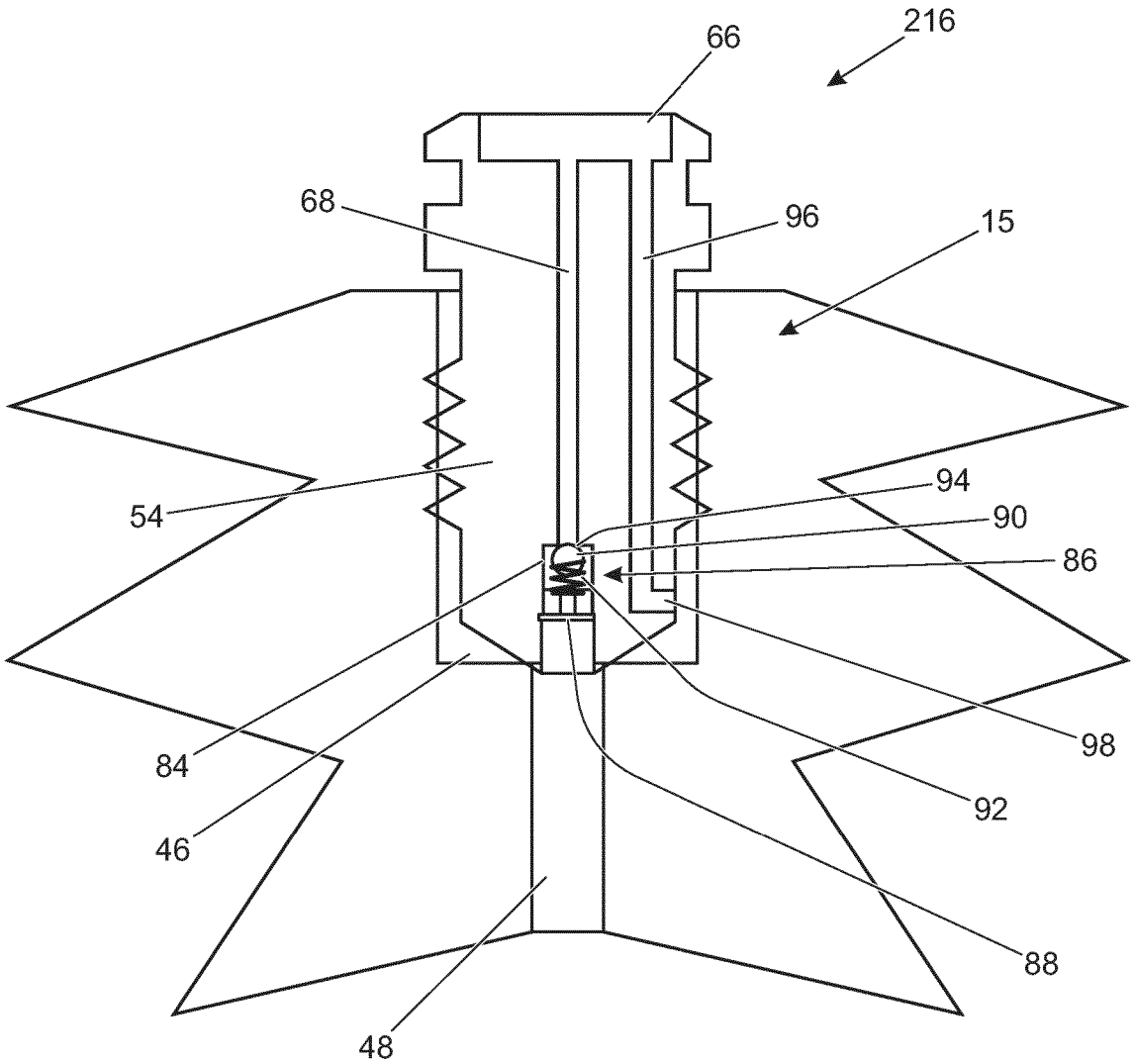

FIG 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/051072

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60T17/22
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/061394 A1 (AWAD ADAM [US]) 24 March 2005 (2005-03-24) paragraph [0035] - paragraph [0042]; figure 1	1-17,24, 25

X	US 5 605 384 A (JOHNSTON GARY L [US] ET AL) 25 February 1997 (1997-02-25)	1,5-9, 13-17,24
A	column 6, lines 16-58; figure 1	2-4, 18-21,25

X	WO 01/51357 A1 (HOLLUB PETER C [US]) 19 July 2001 (2001-07-19)	1,2,5,6, 8,14-16, 24
A	page 4, paragraph 4 - page 5, paragraph 1; figure 1	3,4,7, 9-13, 17-21,25

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 April 2017	05/07/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Raffaelli, Leonardo

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/051072

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 36 33 872 C1 (DAIMLER BENZ AG) 8 October 1987 (1987-10-08)	1
A	paragraph [0002]	2-21,24, 25

A	US 5 497 864 A (OIEN GENE [US]) 12 March 1996 (1996-03-12) columns 3,4; figure 1	1-21,24, 25

A	JP 2009 126428 A (HONDA MOTOR CO LTD) 11 June 2009 (2009-06-11) paragraphs [0028] - [0032]; figure 1	1-21,24, 25

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/051072

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-21, 24, 25

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-21, 24, 25

   a method of filling or refilling a fluid line of a hydraulic fluid

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2. claims: 22, 23

   a bleed valve

   ---

3. claims: 26-29

   a vehicle

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/051072

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005061394 A1	24-03-2005	NONE	
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WO 0151357 A1	19-07-2001	AU 2960501 A	24-07-2001
		CA 2397380 A1	19-07-2001
		EP 1252063 A1	30-10-2002
		US 6302167 B1	16-10-2001
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JP 2009126428 A	11-06-2009	JP 4659016 B2	30-03-2011
		JP 2009126428 A	11-06-2009