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VALVE ASSEMBLY AND PISTON WITH DOUBLE O-RING INTERFACE AND RELIEF PASSAGE

Abstract

A valve assembly includes a housing having an interior wall defining a chamber having a longitudinal axis. A piston is disposed in the chamber and is movable between first and second positions along the longitudinal axis, wherein the piston includes a piston head. The piston head has opposite first and second sides, longitudinally spaced first and second peripheral grooves disposed between the first and second sides, wherein the first and second grooves define a space therebetween, and a relief passage extending radially inwardly from the first groove and communicating between the space and the first side of the piston. Longitudinally spaced first and second O-rings are disposed in the first and second grooves and engage the interior wall.

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Background/Summary

BACKGROUND

[0001] Various systems may incorporate a pneumatic valve configured with a guide piston, including for example and without limitation relay valves and foot brake modules. Such systems may be incorporated as a component of a braking system of a vehicle, such as a tractor/truck that is capable of towing a trailer. Typically, such systems include a piston, which actuates a valve. The piston may be subjected to various forces or moments during operation causing the piston to tilt, which may subject the piston, valve and/or housing to uneven wear.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. **1** is a perspective view of one embodiment of a foot brake module assembly.

[0003] FIG. **2** is a cross-sectional view of the foot brake module assembly of FIG. **1** when a foot brake pedal is not pressed and there is no air flow in primary and secondary circuits of the foot brake module assembly.

[0004] FIG. **3** is an enlarged view of a portion of the foot brake module assembly of FIG. **2**.

[0005] FIG. **4** is a cross-sectional view of FIG. **1** when the foot brake pedal is pressed and there is air flow in the primary circuit but not in the secondary circuit.

[0006] FIG. **5** is an enlarged view of a portion of the foot brake module assembly of FIG. **4**.

[0007] FIG. **6** is a cross-sectional view of FIG. **1** when the foot brake pedal is pressed and there is air flow in both the primary and secondary circuits.

[0008] FIG. **7** is an enlarged view of a portion of the foot brake module assembly of FIG. **6**.

[0009] FIG. **8** is a perspective view of one embodiment of a piston with a relief passage.

[0010] FIG. **9** is a side view of the piston shown in FIG. **8**.

[0011] FIG. **10** is a partial, enlarged perspective view of the piston showing one embodiment of a relief passage.

[0012] FIG. **11** is partial, enlarged side view of the piston and relief passage shown in FIG. **10**.

[0013] FIG. **12** is a cross-sectional view of the piston and relief passage taken along line **12-12** in FIG. **11**.

[0014] FIG. **13** is a partial, enlarged perspective view of the piston showing another embodiment of a relief passage.

[0015] FIG. **14** is partial, enlarged side view of the piston and relief passage shown in FIG. **13**.

[0016] FIG. **15** is a cross-sectional view of the piston and relief passage taken along line **15-15** in FIG. **14**.

[0017] FIG. **16** is a schematic illustration of a relay valve assembly in an applied position.

[0018] FIG. **17** is a schematic illustration of a relay valve assembly in a balance position.

[0019] FIG. **18** is a schematic illustration of a relay valve assembly in an exhaust position.

SUMMARY

[0020] In one aspect, one embodiment of a valve assembly includes a housing having an interior wall defining a chamber having a longitudinal axis. A piston is disposed in the chamber and is movable between first and second positions along the longitudinal axis, wherein the piston includes

a piston head. The piston head has opposite first and second sides, longitudinally spaced first and second peripheral grooves disposed between the first and second sides, wherein the first and second grooves define a space therebetween, and a relief passage extending radially inwardly from the first groove and communicating between the space and the first side of the piston. Longitudinally spaced first and second O-rings are disposed in the first and second grooves and engage the interior wall.

[0021] In another aspect, one embodiment of a piston includes a piston head having opposite first and second sides and longitudinally spaced first and second peripheral grooves disposed between the first and second sides and defining a space therebetween. A relief passage extends radially inwardly from the first groove and communicates between the space and the first side of the piston. Longitudinally spaced first and second are O-rings disposed in the first and second grooves and engaging the interior wall.

[0022] In another aspect, one embodiment of a foot brake assembly includes a valve assembly having a piston with a relief passage, an air supply port, and an air delivery port. The piston is movable between first and second positions to allow air to flow from the air supply port to the air delivery port. In one embodiment, the piston has a supply pressure applied to the first side, wherein the relief passage is in communication with the first side.

[0023] In another aspect, one embodiment of a relay valve assembly includes a piston with a relief passage. The piston is moveable relative to the housing between an applied position and a release position. The piston includes a seat engaged with a valve when the piston is in the applied position, and wherein the seat is disengaged from the valve when the piston is in the release position.

[0024] Various methods of using the valve assembly and piston are also disclosed.

[0025] The various embodiments of the valve assembly, piston, foot brake and relay valve provide significant advantages relative to other valve assemblies and pistons. For example and without limitation, the first and second O-rings resist any tilting of the piston by providing a counter moment. At the same time, the relief passage behind one of the O-rings ensures that air is not trapped between the O-rings, but rather allows the air to escape past the selected O-ring. In one embodiment, the relief passage communicates with the supply side of the piston.

[0026] Other embodiments are possible, and each of the embodiments can be used alone or together in combination.

DETAILED DESCRIPTION

[0027] Referring to FIG. **1**, a foot brake module (FBM) assembly **100** (sometimes referred to herein as a “foot brake assembly” or just a “foot brake module (FBM)” may be used in any suitable vehicle, such as, but not limited to, a tractor/truck that is capable of towing a trailer. The FBM assembly **100** of this embodiment may include mounts **105** for a brake pedal (not shown), primary and secondary supply ports **106**, **107**, and primary and secondary delivery ports **108**, **109**. FIG. **2** is a cross-sectional view of the FBM assembly **100**, and FIG. **3** is an enlarged view of a portion of the FBM assembly **100**. As shown in FIG. **2**, in this embodiment, the first circuit of the FBM assembly **100** includes a primary piston **110** positioned in a primary guide sleeve **111**, a primary valve collar **112**, and a primary valve seat **113**. Similarly, the second circuit of the FBM assembly **100** comprises a secondary (relay) piston **120** positioned in a secondary guide sleeve **121**, a secondary valve collar **122**, and a secondary valve seat **123**.

[0028] In one embodiment, as shown in FIGS. **2-7**, the FBM is configured as a valve assembly **401** having a housing **400** with an interior wall **402** defining a chamber **404**. The chamber **404** extends along a longitudinal axis **406**. A piston **120** is moveably disposed in the chamber **404** and is movable between first and second positions along the longitudinal axis **406** as further explained below. The piston **120** divides the chamber **404** between first and second cavities.

[0029] In another embodiment, shown in FIGS. **16-18**, a relay valve assembly **601** is shown as including a housing **600** having an interior wall **602** defining a chamber **604**. The chamber **604** extends along a longitudinal axis **606**. A piston **720** is moveably disposed in the chamber **604** and is

movable between first and second positions (e.g., applied, balanced and exhaust/relief positions) along the longitudinal axis **606** as further disclosed below.

[0030] Referring to FIGS. **8-18**, the piston **120**, **720** includes a piston head **412**, **612** having opposite first and second sides **408**, **410**, **608**, **610**. The piston head **412**, **612** further includes a peripheral side edge **414**, **614**, defined as a circumferential surface in one embodiment. First and second peripheral and circumferential grooves **416**, **418**, **616**, **618** are longitudinally spaced along the longitudinal axis **406**, **606** and are disposed between the first and second sides **408**, **410**, **608**, **610**. The first and second grooves **416**, **418**, **616**, **618** define a space **420**, **620** therebetween, or are spaced apart, for example by a circumferential rib **422**, **622**. In operation, the rib **422**, **622** does not engage the interior wall **402**, **602**, thereby defining the space **420**, **620** between the grooves.

[0031] A relief passage **424**, **426**, shown in FIGS. **8** and **10-15** and otherwise referred to as a vent, extends radially inwardly from the first groove **416**, **616** and is in fluid communication between the space **420**, **620** and the first side **408**, **608** of the piston head **412**, **612**. In other embodiments, the relief passage may be instead be formed in, or behind (i.e., radially inwardly from), the second groove **418**, **618**. The term “fluid” refers to a gas or liquid. As shown in FIG. **8**, the piston **120**, **720** may be configured with a plurality of relief passages **424** in or behind the groove **416**, **616**. The term “plurality” refers to two or more. In one embodiment, the piston **120**, **720** includes a pair of relief passages **424**, **426** circumferentially spaced, for example and without limitation at 180 degrees, on the first groove **416**, **616**. It should be understood that a single relief passage or more than two relief passages, may be suitable. In addition, the relief passage(s) may be configured with different circumferential lengths, or have deeper or more shallow undercuts, so as to optimize the cross-sectional flow area and ensure proper air flow for adequate venting and avoiding any trapped pressurized air, It should be understood that either or both relief passages **424**, **426** may be formed in either or both of the grooves **416**, **616**.

[0032] The first groove **416**, **616** may be defined by an upper wall **428**, **628** longitudinally spaced from a lower wall **430**, **630** and a circumferential side wall **432**, **632**. In one embodiment, the relief passage **424**, **426** is defined by a continuous undercut **440**, **450** formed in the upper and lower walls **428**, **628**, **430**, **630** and the side wall **432**, **632**. As a result of the undercut **440**, **450**, first and second openings **460**, **462**, **660**, **662** are defined in the upper and lower walls **428**, **628**, **430**, **630** at the circumferential periphery of the piston head **412**, **612**. In one embodiment, shown in FIGS. **10** and **11**, the first and second openings **460**, **462** have a rectangular cross-section, with a linear surface. In another embodiment, shown in FIGS. **13** and **14**, the first and second openings **660**, **662** have a curved surface and a circular segment cross-section. It should be understood that the openings may be configured with any suitable shape, preferably without sharp corners or edges. The first and second openings **460**, **462**, **660**, **662** may have first and second cross-sectional areas between 0.20 mm.sup.2 and 2.00 mm.sup.2. Referring to FIGS. **12** and **15**, the undercut **470**, **670** in the side wall **432**, **632**, which may have a linear surface (FIG. **15**) or curved surface (FIG. **12**) has a cross-sectional area of between 0.20 mm.sup.2 and 2.00 mm.sup.2. The first and second openings **460**, **462**, **660**, **662** communicate (i.e., are in fluid communication) with the chamber **404**, **604** and space **420**, **620** respectively.

[0033] Referring to FIGS. **2-9**, the piston **120** includes a shaft **200** extending from the first side **408** of the piston head **412**, wherein the shaft is positioned in a guide sleeve **111**. Longitudinally spaced first and second O-rings **500**, **502** are disposed in the first and second grooves **416**, **418** and engage the interior wall **402** of the chamber **404**. The second O-ring **502** seals the piston against the interior wall of the chamber. The first O-ring **500** acts as a guide to counter any moments applied to the piston **120** and prevent tilting thereof. The first O-ring does not act as a seal against the interior wall **402**, **602** of the chamber **404**, **604** due to the relief passage(s) **424**, **426**, which act as a vent between the space **420** between the O-rings **500**, **502** and the chamber **404** on the first side **408** of the piston **120**. In this way, air is prevented from being trapped between the O-rings **500**, **502** and thereby creating unnecessary friction. Instead, the air may pass through the relief passage **424**, **426**,

or vent, and into the chamber **404**. The chamber may define the primary delivery air passage, and may be pressurized or have a pressure greater than the pressure on the other side of the piston **120**. As shown in FIGS. **2**-**14**, the relief passage **424**, **426**, or vent, is positioned radially inwardly from the groove **416**, **616** and inner diameter of the O-ring **500** disposed therein. In other embodiments, the primary piston **110** may also be configured with a double O-ring interface, including a vent between the space defined between the O-rings and a chamber on the other side of one of the O-rings. It should be understood that in various applications, the space between the O-rings may be vented to one or the other of the sides of the piston past either the first or second O-ring depending on the application and the system parameters, including for example the pressures acting on the piston.

[0034] In the configuration shown in FIGS. **2** and **3**, the foot brake pedal is not pressed and there is no air flow in primary and secondary circuits. That is, in the primary circuit, the primary valve collar **112** is pressed against the primary valve seat **113**, preventing air flow from the primary supply port **106** to the primary delivery port **108**. Similarly, in the secondary circuit, the secondary valve collar **122** is pressed against the secondary valve seat **123**, preventing air flow from the secondary supply port **107** to the primary delivery port **109**.

[0035] FIGS. **4** and **5** illustrate the operation when the foot brake pedal is pressed and there is air flow in the primary circuit but not in the secondary circuit. As shown in these drawings, when the brake pedal is pressed, force is applied to a thrusting member to move the primary piston **110** downward, which moves the primary valve collar **112** away from the primary valve seat **113**. As indicated in FIGS. **4** and **5**, this creates an opening **115** for air to flow from the primary supply port **106** to the primary delivery port **108**. At this point, the secondary valve collar **122** is still pressed against the secondary valve seat **123**, preventing air flow from the secondary supply port **107** to the primary delivery port **109**. However, the movement of the primary piston **110** downward also creates an opening **118** through which air from the primary supply port **106** fills the chamber **404** containing the secondary piston **120**. As shown in FIGS. **6** and **7**, when the pressure in the chamber **404** reaches a threshold, the air in the chamber **404** serves as a pilot to push the secondary piston **120** downward from a first position to a second position, which moves the secondary valve collar **122** away from the secondary valve seat **123**. As indicated in FIGS. **6** and **7**, this creates an opening **125** for air to flow from the secondary supply port **107** to the secondary delivery port **109**, actuating the secondary braking circuit. In one embodiment, the threshold pressure is between about 12 and 17 psi, although it should be understood that higher or lower threshold pressures may be desired and implemented.

[0036] In some embodiments, the secondary piston **120** is aligned at the first position in FIG. **3** and realigns itself when it reaches the second position in FIG. **7**, but is susceptible to tilting in the “free state” in between the first and second positions. This titling can be caused by a moment created by a return spring **170** positioned around the secondary piston **120**. If the secondary piston **120** tilts too far during its travel, the sealing surface interference, defined for example by the O-ring **502**, may be compromised on one side of the secondary piston **120**, causing air from the primary and/or secondary supply ports **106**, **107** to exhaust through at the bottom of the FBM assembly **100** (i.e., opening up the exhaust path and allowing air flow out the bottom vent), which can be audible. Such tilting may also create wear on the secondary piston **120**. To help center the secondary piston **120** as it travels and overcome these problems, the pair of O-rings **500**, **502** provides stability, while the relief passages **424**, **426** preventing air from being trapped between the O-rings **500**, **502** and thereby creating additional friction, while the O-ring **502** continues to function as a sealing member.

[0037] Referring again to the valve assembly **601** of FIGS. **16**-**18**, a biased double-check valve ensures that a primary service signal controls the valve. The relay valve assembly **601** may be connected to the FBM assembly **100**, or valve assembly **401**. In an applied position shown in FIG. **16**, a pressurized air supply is delivered to a primary service port **800** and enters the chamber **604**

above the piston **720** and moves the piston **720** in the chamber **604**. An exhaust seat **802** moves with the piston and seats on the inner or exhaust portion of the inlet/exhaust valve **804**, sealing off an exhaust passage **826**. At the same time, an outer or inlet portion of the inlet/exhaust valve **804** moves off its seat **806**, permitting supply air to flow from a reservoir **808**, past the open inlet valve **804** and into one or more service brake chambers **810**.
[0038] In a balanced position, shown in FIG. **17**, the air pressure being delivered by the open inlet valve **804** also is effective on the bottom area of the relay piston. When air pressure beneath the piston equals the service air pressure above, the piston **720** lifts slightly and the inlet spring **812** returns the inlet valve **804** to its seat **806**. The exhaust remains closed as the service line pressure balances the delivery pressure. As delivered air pressure is changed, the valve **804** reacts instantly to the change, holding the brake application at that level.
[0039] In a relief or exhaust position, shown in FIG. **18**, the air pressure is released from the service ports **800**, air pressure in the chamber **604** above the relay piston **720** is exhausted through the primary circuit of the brake valve. At the same time, air pressure beneath the piston **720** lifts the relay piston and the exhaust seat **802** moves away from the exhaust valve **804**, opening the exhaust passage **824**. With the exhaust passage **824** open, the air pressure in the brake chambers is then permitted to exhaust through the exhaust port **826**, releasing the brakes.
[0040] The pair of O-rings **500**, **502** again provide increased stability to the piston **720**, while still maintaining an appropriate seal with the O-ring **502** and venting through the relief passages **424**, **426** to the chamber.
[0041] It should be understood that all of the embodiments provided in this Detailed Description are merely examples and other implementations can be used. Accordingly, none of the components, architectures, or other details presented herein should be read into the claims unless expressly recited therein. Further, it should be understood that components shown or described as being "coupled with" (or "in communication with") one another can be directly coupled with (or in communication with) one another or indirectly coupled with (in communication with) one another through one or more components, which may or may not be shown or described herein.
[0042] It is intended that the foregoing detailed description be understood as an illustration of selected forms that the invention can take and not as a definition of the invention. It is only the following claims, including all equivalents, which are intended to define the scope of the claimed invention. Accordingly, none of the components, architectures, or other details presented herein should be read into the claims unless expressly recited therein. Finally, it should be noted that any aspect of any of the embodiments described herein can be used alone or in combination with one another.

Claims

1. A valve assembly comprising: a housing comprising an interior wall defining a chamber having a longitudinal axis; a piston disposed in the chamber and movable between first and second positions along the longitudinal axis, wherein the piston comprises a piston head comprising: opposite first and second sides; longitudinally spaced first and second peripheral grooves disposed between the first and second sides, wherein the first and second grooves define a space therebetween; and a relief passage extending radially inwardly from the first groove and communicating between the space and the first side of the piston; and longitudinally spaced first and second O-rings disposed in the first and second grooves and engaging the interior wall.
2. The valve assembly of claim 1 wherein the relief passage comprises a first relief passage, and further comprising a second relief passage circumferentially spaced from the first relief passage.
3. The valve assembly of claim 1 wherein the first groove is defined by longitudinally spaced upper and lower walls and a circumferential side wall, wherein the relief passage comprises a continuous undercut formed in the upper and lower walls and the side wall.

4. The valve assembly of claim 3 wherein the upper and lower walls comprise first and second openings defined by the undercut at a circumferential periphery of the piston head.
5. The valve assembly of claim 4 wherein the first and second openings have first and second cross-sectional areas between 0.20 mm.sup.2 and 2.00 mm.sup.2.
6. The valve assembly of claim 3 wherein the undercut in the side wall has a cross-sectional area of between 0.20 mm.sup.2 and 2.00 mm.sup.2.
7. The valve assembly of claim 1 wherein the piston comprises a shaft extending from the first side of the piston head, wherein the shaft positioned in a guide sleeve.
8. A foot brake assembly comprising the valve assembly of claim 1, and further comprising: at least one air supply port; and at least one air delivery port; wherein the piston is movable between first and second positions to allow air to flow from the air supply port to the air delivery port.
9. The foot brake assembly of claim 8 wherein a first pressure is applied to the first side of the piston and a second pressure is applied to the second side, wherein the first pressure is greater than the second pressure.
10. A relay valve assembly comprising the valve assembly of claim 1 wherein the piston is moveable relative to the housing between an applied position, a balanced position and a release position, wherein the piston comprises a seat engaged with a valve when the piston is in the applied position, wherein the seat is disengaged with the valve when the piston is in the balanced position, and wherein the seat is disengaged from the valve when the piston is in the release position, and wherein the valve is seated against a valve seat when the piston is in the balanced and release positions.
11. A piston comprising: a piston head comprising: opposite first and second sides; longitudinally spaced first and second peripheral grooves disposed between the first and second sides, wherein the first and second grooves define a space therebetween; and a relief passage extending radially inwardly from the first groove and communicating between the space and the first side of the piston; and longitudinally spaced first and second O-rings disposed in the first and second grooves and engaging the interior wall.
12. The piston of claim 11 wherein the relief passage comprises a first relief passage, and further comprising a second relief passage circumferentially spaced from the first relief passage.
13. The piston of claim 11 wherein the first groove is defined by longitudinally spaced upper and lower walls and a circumferential side wall, wherein the relief passage comprises a continuous undercut formed in the upper and lower walls and the side wall.
14. The piston of claim 13 wherein the upper and lower walls comprise first and second openings defined by the undercut at a circumferential periphery of the piston head.
15. The piston of claim 14 wherein the first and second openings have first and second cross-sectional areas between 0.20 mm.sup.2 and 2.00 mm.sup.2.
16. The piston of claim 13 wherein the undercut in the side wall has a cross-sectional area of between 0.20 mm.sup.2 and 2.00 mm.sup.2.
17. The piston of claim 11 wherein the piston comprises a shaft extending from one of the first and/or second sides of the piston head.
18. The piston of claim 11 wherein the piston comprises a seat positioned on one of the first and/or second sides of the piston head.