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(54) **Piston accumulator**

(57) A piston accumulator (40) for damping two fluid systems is provided. The piston accumulator (40) comprises a cylinder (42), a first port (44) for a fluid system to be damped, which is disposed at one end of the cylinder (42), and a first piston (52), which is contained in a sealed manner and slidably in the cylinder (42). Furthermore, the piston accumulator (40) comprises a second port (46) for a second fluid system to be damped, which is disposed at the other end of the cylinder (42), and a second piston (54), which is contained in the cylinder (42) in a sealed manner and is slideable between the first piston (52) and the second port (46). A first damping volume (60), formed between the first (52) and the second piston (54), is or can be filled with fluid, preferably gas. The accumulator further comprises a third piston (68), which is contained in the cylinder (42) in a sealed manner and is slideable between the second piston (54) and the second port (46), wherein a second damping volume (70), formed between the second (54) and the third (68) piston, is or can be filled with fluid.

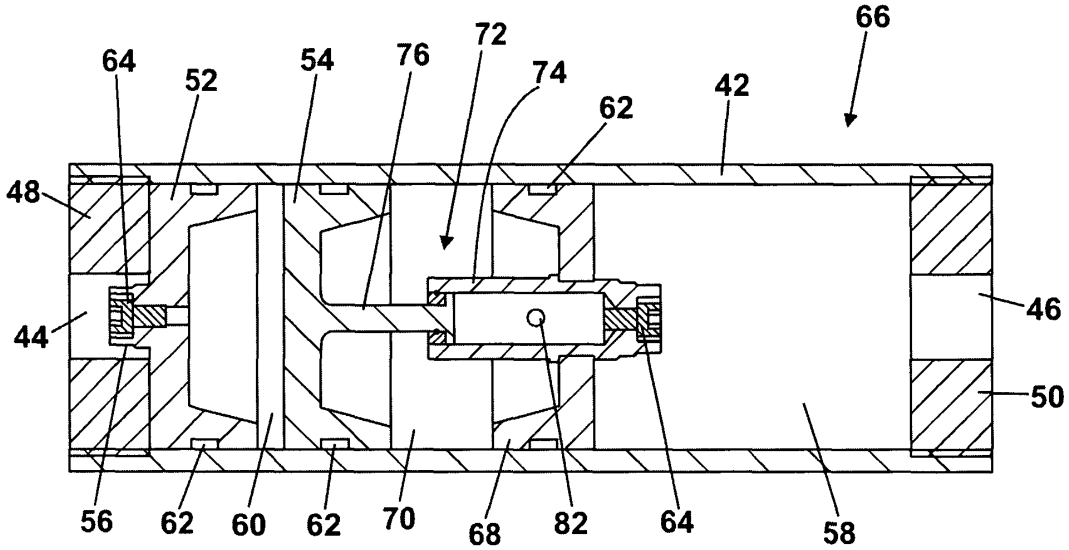

Fig. 4A

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Description

[0001] The present invention relates to a piston accumulator for damping two fluid systems and a piston accumulator for damping one fluid system, wherein the piston accumulator comprises a cylinder, a first port for a fluid system to be damped, which is disposed at one end of the cylinder, and a first piston, which is contained in a sealed manner and is slideable in the cylinder.

[0002] In the case of vehicles with extension arms, which are hydraulically raised and lowered, as for example agricultural vehicles with front loaders, frequently damping systems are used in order to damp the oscillations of the extension arm arising during travel. Such oscillations arise in particular during fast travel and high loading of the extension arm. Pressure peaks in the hydraulic system are damped and smoothed out by the damping systems. As a result of such damping systems travel comfort and safety are improved.

[0003] Fig. 1 schematically illustrates a hydraulic system for raising and lowering an extension arm, as it is used up to now in the prior art. Two hydraulic cylinders 2, 4, which are each divided by a piston 6 into a first piston chamber 8 and a second piston chamber 10, serve for raising and lowering the extension arms. The first piston chambers 8 have a first port B1 or B2 in each case, through which hydraulic fluid, in particular hydraulic oil, can be supplied from the hydraulic system 14 of the vehicle via a fluid line B and a valve 12. A supply of hydraulic fluid via the fluid line B and the two first ports **B1, B2** to the first piston chambers 8 leads to displacement of the pistons 6 in Fig. 1 towards the right (see arrow 16). Therefore, in the present case the extension arm, in particular a front loader, is raised.

[0004] In each case second ports A1 or A2, which are connected by a common second fluid line A to the hydraulic system 14 of the vehicle, are provided on the two second piston chambers 10. The piston 6 is displaced towards the left in Fig. 1 (see arrow 18) by a supply of hydraulic fluid via the second fluid line A and the second ports A1, A2 to the second piston chamber 10. Therefore in the present case the extension arm, in particular the front loader, is lowered.

[0005] Furthermore, oscillation dampers in diaphragm construction are provided in the present example. A first hydraulic accumulator 20 and a second hydraulic accumulator 22 on the first fluid line B are connected in parallel to each other to produce a compound damping characteristic. A third hydraulic accumulator 24 is connected to the second fluid line A. As generally known from the prior art, such hydraulic accumulators 20, 22, 24 have a diaphragm, which is disposed in an enclosed space and which is impacted from one side with a charging pressure of a gas volume enclosed on this side and which is impacted from the other side with the pressure of the hydraulic fluid, which is supplied via a port (here from the fluid line A or B). Damping behaviour, which substantially corresponds to a linear spring characteristic, can be achieved by providing a charging pressure differential in the two hydraulic accumulators 20 and 22.

[0006] Accordingly in the example illustrated, pressure peaks in the fluid line B are damped predominantly by the two hydraulic accumulators 20, 22 while pressure peaks in the fluid line A are damped predominantly by the hydraulic accumulator 24. Due to the dead weight of the extension arm higher pressure peaks normally arise in the fluid line B, so that the provision in this fluid line of two hydraulic accumulators, one of which preferably has a higher charging pressure, is particularly advantageous. As mentioned above, travel comfort and safety are substantially improved by the damping provided. Furthermore in the case of extension arms and particularly front loaders a mechanical end stop, by means of which the raising of the extension arm is limited, is normally provided. If the extension arm is driven against the end stop while being raised, pressure peaks arise in the fluid line A, which are then damped by the hydraulic accumulator 24. Thus mechanical stress on the end stops is reduced.

[0007] Apart from the arrangement illustrated in Fig. 1 hydraulic systems, wherein only one or no oscillation damper is provided for each fluid line, are also used. Additionally, piston accumulators are sometimes used in place of the hydraulic accumulators 20, 22 and 24. A corresponding hydraulic system, as used for example for raising and lowering an extension arm, particularly a front loader, is illustrated in Fig. 2. In place of the hydraulic accumulators 20, 22 and 24 piston accumulators 26, 28, 30 respectively are provided in this case. Apart from this the arrangement illustrated in Fig. 2 substantially corresponds to the arrangement illustrated in Fig. 1, so that the same reference symbols are used for identical components and explanation of the identical components is omitted. The piston accumulators normally used are formed in each case by a cylinder 32, which by a piston 34 slidably arranged therein, is divided into a first chamber 36 and a second chamber 38. While the first chamber 36 is connected to the fluid line B or A respectively, the second chamber is closed in a sealed manner and filled with a gas at a designated charging pressure.

[0008] A substantial advantage of piston accumulators compared to hydraulic accumulators is that piston accumulators permit a high ratio between the operating pressure (equates to the pressure in the fluid line A or B) and the charging pressure (equates to the pressure in the second chamber 38), in particular a pressure ratio of approximately 10:1. Furthermore, such piston accumulators are resistant to outside forces and tolerate fluctuations in the system pressure. Due to these properties piston accumulators are mainly used in construction equipment having higher operating pressures. When used for front loaders of tractors the operating pressure is approximately 100-200 bar, in the case of construction equipment (wheel loaders) up to 450 bar. Compared to hydraulic accumulators, however, the cost per unit of such piston accumulators is higher.

[0009] GB-2,420,380 discloses an accumulator having two pistons. Three chambers are formed in the cylinder by the provision of the two pistons. A first chamber is formed in the cylinder between the first port and the first piston. This chamber forms a first active volume, which communicates via the first port with the first fluid system. A second chamber is formed in the cylinder between the first and the second piston. The third chamber is finally formed in the cylinder between the second piston and the second port, which provides a second active volume, which communicates via the second port with the second fluid system. The second chamber, which is filled with gas thereby forms a damping volume. For example, the first piston is displaced towards the second piston whenever pressure peaks arise in the first fluid system and thus the damping volume is compressed. Vice versa whenever pressure peaks arise in the second fluid system, the second piston is displaced towards the first piston and the fluid contained in the second chamber is compressed.

[0010] According to the present invention a piston accumulator for damping two fluid systems is provided, which comprises a cylinder, a first port for a fluid system to be damped, which is disposed at one end of the cylinder, a first piston, which is contained in a sealed manner and slidably in the cylinder, a second port for a second fluid system to be damped, which is disposed on the other end of the cylinder, and a second piston, which is contained in the cylinder in a sealed manner and is slideable between the first piston and the second port, wherein a first damping volume, formed between the first and the second piston, is filled or can be filled with fluid, preferably gas. The piston accumulator according to the invention further comprises a third piston, which is contained in the cylinder in a sealed manner and is slideable between the second piston and the second port, wherein a second damping volume, formed between the second and the third piston, is filled or can be filled with fluid, preferably with gas.

[0011] Compared to the arrangement with only two pistons, in this case a further chamber, which can be used for damping, is formed. Such an arrangement, in particular by providing corresponding stops or by providing corresponding coupling between at least two of the pistons, with un-pressurized first and second port, permits the pressure in the one damping volume to be lower than the pressure in the other damping volume. Thus a compound damping characteristic can be produced, as is known for example in the case of conventional hydraulic accumulators connected in parallel or piston accumulators with differential charging pressures. In particular therefore damping behaviour, which substantially corresponds to a linear spring characteristic can be obtained.

[0012] "Disposed at one end of the cylinder" in the present context means that the ports are arranged in the vicinity of the respective end, so that they lie further outwards on the cylinder than the respective adjacent piston.

[0013] According to an advantageous further embodiment of the invention the first and second pistons in each case have the same diameter. It is preferable if all pistons have the same diameter. Thus simple construction of the cylinder and the piston contained therein is permitted.

[0014] According to an advantageous further embodiment of the invention the cylinder is sealed at both ends in each case by a plug, wherein preferably one port is provided in each plug. Thus particularly simple and economic manufacture of the piston accumulator is possible.

[0015] According to an advantageous further embodiment of the invention such a differential pressure is achieved in the first and the second damping volume (with un-pressurized first and second port) due to the fact that the second piston and the third piston are coupled together via a displacement limitation device, by means of which a maximum relative displacement between the second and the third piston is defined. In this case provision can be made for the displacement limitation device to comprise a guide connected to one of the second and the third piston and a guide device connected to the other of the second and the third piston, wherein the guide device can be moved in the guide along the displacement direction of the pistons over the length of the maximum relative displacement. The guide can be formed for example as a cylinder or as a rail. The guide device can be formed correspondingly as a piston or as a rider, which is contained slidably in the cylinder or in the rail. Furthermore, stops may be provided on the guide, by means of which the maximum relative displacement is limited. Preferably, the maximum relative displacement can be varied, so that different damping characteristics can be adjusted.

[0016] Alternatively or additionally, provision is made for the movement of the second and/or the third piston along the displacement direction of the pistons to be limited by a stop. This stop may be provided for example on the cylinder. Preferably, the position of the stop can be varied. By providing such a stop, different damping characteristics for the first and the second fluid system can be made available. In contrast to this, just by providing the displacement limitation device described above identical damping behaviour for the first and the second fluid system is achieved.

[0017] According to an advantageous further embodiment the pressure in the first damping volume, with un-pressurized first and second port, lies in a range of substantially 18 - 26 bar, preferably in a range of substantially 20 - 24 bar, and the pressure in the second damping volume in a range of substantially 31 - 39 bar, preferably in a range of substantially 33 - 37 bar. Consequently, as described above in respect to the hydraulic accumulators connected in parallel, a compound damping characteristic can be produced. Un-pressurized first and second port in the present context is understood to mean that the two ports are at atmosphere, that is to say, at approximately 1 bar. The indicated pressure values of 18 - 26 bar or 20 - 24 bar and 31 - 39 bar or 33 - 37 bar in this case are the differential pressures in relation to atmosphere. Accordingly, the absolute pressures would be 19

- 27 bar or 21 - 25 bar and 32 - 40 bar or 34 - 38 bar.

[0018] According to an advantageous further embodiment of the invention at least one of the pistons comprises an orifice, which can be closed by a plug, preferably a screw plug, through which a damping volume, adjacent to the respective piston, can be filled with gas.

[0019] Preferably, the piston accumulator according to the invention is used in combination with a hydraulic cylinder, comprising a first and a second piston chamber, which can be impacted with fluid pressure for adjusting the hydraulic cylinder in each case, wherein the first piston chamber of the hydraulic cylinder is or can be brought in fluidic communication with the first port of the piston accumulator, and wherein the second piston chamber is or can be brought in fluidic communication with the second port of the piston accumulator. Thus, a damped hydraulic system, in which both sides of the hydraulic cylinder are damped, is made available, only one piston accumulator being necessary for producing such an oscillation damping.

[0020] According to an advantageous further embodiment of the invention a utility vehicle, in particular an agricultural vehicle, which comprises an extension arm, preferably a front loader, at least one hydraulic cylinder for raising and lowering the extension arm and a piston accumulator according to the invention is made available. The hydraulic cylinder here comprises a first and a second piston chamber, which can be impacted respectively with fluid pressure for adjusting the hydraulic cylinder, wherein the first piston chamber is or can be brought in fluidic communication with the first port of the piston accumulator, and wherein the second piston chamber is or can be brought in fluidic communication with the second port of the piston accumulator. Thus, oscillation damping is produced on both sides of the hydraulic cylinder, wherein only one piston accumulator must be provided for this. As a result, cost and space are saved. Equally, the piston accumulator according to the invention is advantageous for damping two hydraulic cylinders, which in each case are used for raising and lowering an extension arm and are connected in parallel to each other.

[0021] Furthermore, according to the present invention a piston accumulator for damping one fluid system is made available, which comprises a cylinder, a port for the fluid system to be damped, which is disposed at one end of the cylinder, wherein the end of the cylinder facing the port is closed, and a first piston which is contained in a sealed manner and is slideable in the cylinder. Furthermore, the piston accumulator according to the invention comprises at least a second piston, which is contained in the cylinder in a sealed manner and is slideable between the first piston and the closed end of the cylinder, wherein a first damping volume, formed between the first and the second piston, is filled or can be filled with fluid, preferably gas, and wherein a second damping volume, formed between the second piston and the closed end of the cylinder, is filled or can be filled with fluid, preferably gas.

[0022] Consequently, a piston accumulator, which corresponds to two conventional accumulators (hydraulic accumulator or piston accumulator) with differential charging pressures is made available. Thus, cost and space can again be saved. The advantages and further embodiments explained above regarding the piston accumulator for damping two fluid systems can also be realized with the piston accumulator for damping one fluid system. If, however, a plug is provided according to Claim 3, a port is disposed in only one plug. If a third piston is provided according to Claim 1, this is disposed between the second piston and the closed end of the cylinder, so that a second and a third damping volume are formed. A displacement limitation device according to Claim 4 or 5 can be provided both between the second and the third piston, and between the piston, which is adjacent to the closed end of the cylinder, and the closed end of the cylinder. With regard to Claims 7 and 8 if three pistons are provided a differential pressure can be provided in the three damping volumes. Furthermore, the piston accumulator according to the invention can also be used for damping a fluid system in a damped hydraulic system according to Claim 11 and in a utility vehicle according to Claim 12 or 13. In this case, one separate piston accumulator only has to be provided for each piston chamber of the hydraulic cylinder.

[0023] Further characteristics and advantages of the invention will be evident from the description of exemplary embodiments with reference to the appended drawings, wherein:

- Fig. 1 shows a schematic illustration of a hydraulic system for raising and lowering an extension arm according to the prior art;
- Fig. 2 a further schematic illustration of a hydraulic system for raising and lowering an extension arm according to the prior art;
- Fig. 3 a cross sectional view of a piston accumulator having two pistons;
- Fig. 4A a cross sectional view of a piston accumulator according to a first embodiment of the present invention in a first position;
- Fig. 4B the piston accumulator, illustrated in Fig. 4A, in a second position;
- Fig. 4C an enlarged illustration of a cutaway from Fig. 4A;
- Fig. 5 a cross sectional view of a piston accumulator according to a second embodiment of the present invention;
- Fig. 6 a schematic illustration of a hydraulic system with different embodiments of a piston accu-

mulator according to the invention as an oscillation damper;

Fig. 7 a schematic illustration of a hydraulic system for comparison;

Fig. 8A a cross sectional view of a piston accumulator according to a third embodiment of the present invention in a first position; and

Fig. 8B the piston accumulator, illustrated in Fig. 8A, in a second position.

[0024] Fig. 3 illustrates a piston accumulator 40 comprising a cylinder 42, a first port 44 on the one end of the cylinder 42 and a second port 46 on the other end of the cylinder 42. The ports 44 and 46 in this case are each formed in a screw plug 48 or 50, by means of which the cylinder 42 is closed on both sides. Preferably, after the components disposed in the cylinder 42 have been located, the screw plugs 48 and 50 are welded inseparably to .the cylinder 42. A first piston 52 is contained in a sealed manner and is slideable in the cylinder 42. Furthermore, a second piston 54, which is contained in the cylinder 42 in a sealed manner and is slideable between the first piston 52 and the second port 46 (or the screw plug 50), is provided. The first port 44 makes the connection to a first fluid system to be damped, while the second port 46 makes the connection to a second fluid system to be damped.

[0025] Accordingly, a first active volume 56, which can be increased depending upon the pressure in the first fluid system by displacing the first piston 52 towards the second port 46, is formed in the cylinder 42 between the first screw plug 48 and the first piston 52. Equally, a second active volume 58 which can be increased depending upon the pressure in the second fluid system by displacing the second piston 54 towards the first port 44 is formed in the cylinder 42 between the second screw plug 50 and the second piston 54.

[0026] A first damping volume 60, which is filled with fluid, preferably with gas, at least during use of the piston accumulator 40, is formed in the cylinder 42 between the first piston 52 and the second piston 54. When pressure peaks arise in the first fluid system, the first piston 52 in Fig. 3 is displaced towards the right and the first damping volume 60 is compressed. Depending upon the pressure in the second active volume 58 the second piston 54 in Fig. 3 is also as the case may be displaced towards the right. Vice versa when pressure peaks arise in the second fluid system the second piston 54 in Fig. 3 is displaced towards the left and the first damping volume 60 is compressed. Depending in each case upon the pressure prevailing in the first fluid system the first piston 52 is also displaced somewhat to the left. Accordingly damping for two fluid systems can be made available by providing only one piston accumulator 40. The damping behaviour of this piston accumulator 40 in this case corresponds largely to damping behaviour produced in each case by connecting a conventional hydraulic accumulator or piston accumulator with the same charging pressure to the first and the second fluid system respectively.

[0027] The pistons 52, 54 are each provided with piston sealing rings 62, to ensure sliding quality, seal and abrasion resistance. The two pistons 52 and 54 centrally in each case have one screw plug 64. By removing the screw plug 64 an orifice is exposed, which makes a connection between the adjacent active volume 56 or 58 and the first damping volume 60. If the adjacent connection flange is separated from the port 44 or 46, the first damping volume 60 can be filled with gas via the port 44 or 46 and the exposed orifice. In the embodiment, which is illustrated in Fig. 3, the provision of only one screw plug 64 in one of the pistons 52 or 54 is sufficient. If the two ports 44 and 46 are kept un-pressurized (that is to say at atmosphere, substantially 1 bar), the pressure in the first damping volume 60 is preferably adjusted to 22 bar (that is to say 22 bar differential pressure in relation to atmosphere).

[0028] In the following description of embodiments of the present invention the same reference symbols are used for identical components. Below, the differences of these embodiments are primarily discussed in relation to the arrangement shown in Figure 3.

[0029] Figs. 4A to 4C illustrate a piston accumulator 66 according to the invention according to a first embodiment of the present invention. Compared to the accumulator of Figure 3, in the case of the piston accumulator 66 a third piston 68, which is contained slidably in the cylinder 42 between the second piston 54 and the second port 46 (or the second screw plug 50), is provided. Thus, a second damping volume 70 is formed between the second piston 54 and the third piston 68, which is filled with fluid, preferably gas, at least during use. In the present exemplary embodiment the second damping volume 70 is also filled with a charging pressure of 35 bar, whilst the first damping volume 60 is filled with a charging pressure of 22 bar. These values are differential pressures in relation to atmosphere and apply with ports 44 and 46 being kept un-pressurized (that is to say, at substantially 1 bar).

[0030] In order to prevent equal pressure between the two damping volumes 60 and 70, a displacement limitation device 72 is provided between the second piston 54 and the third piston 68 in the present embodiment. A maximum relative displacement between the second (54) and the third (68) piston is defined by the displacement limitation device 72. The displacement limitation device 72 has a cylindrical guide 74 connected to the third piston 68, which as an adapter is screwed into the third piston 68. The second piston 54 comprises a guide device 76, which is incorporated with the piston, whose piston-shaped end is seated in the guide 74 and can be moved therein along the displacement direction of the pistons. The guide 74 comprises a movement stop in both directions. In the displacement direction of the second piston 54 to the first port 44, a stop is formed on the guide 74 by two half-washers 78 and a circlip 80 (see Fig. 4C). Along the displacement direction of the second piston 54 to the second port 46 the movement is limited by the contour of the guide 74. The ratio between the charging pressures in the two damping volumes 60 and 70 can be varied by corresponding adjustment of the maximum displacement length of the guide device 76 in the guide 74.

[0031] A central screw plug 64, through which the second damping volume 70 can be filled from the second port 46, is provided in the guide 74. In order to make a fluid connection between the inside of the cylindrical guide 74 and the second damping volume 70, an orifice 82 is provided in the cylindrical part of the guide 74. This is particularly evident from the enlarged illustration of Fig. 4C.

[0032] The functional mode of the first embodiment, wherein the piston accumulator 66 is connected to a hydraulic system, as illustrated in Fig. 6, is explained below. The hydraulic system of Fig. 6 in this case substantially corresponds to the hydraulic system as illustrated in Figs. 1 and 2. The three hydraulic accumulators 20, 22, 24 in Fig. 1 have only been replaced by a piston accumulator 66 according to the invention. The first port 44 of the piston accumulator 66 in this case is connected to the fluid line B. The second port 46 is connected to the fluid line A. A substantially constant operating pressure of 100 bar is assumed in the fluid line A and thus at the port 46. If however pressure peaks arise in the fluid line A, the third piston 68 is displaced towards the first port 44. Since with the present exemplary embodiment the higher charging pressure of substantially 35 bar prevails in the second damping volume 70, the second piston 54 is also displaced towards the first port 44. Initially, the first damping volume 60 with a charging pressure of substantially 22 bar is compressed accordingly, until the same pressure as in the second damping volume 70 substantially prevails in the first damping volume 60. If pressure peaks arise in the fluid line A, initially the first damping volume 60 with the lower charging pressure damps and only afterwards the two damping volumes 60 and 70 together. The characteristic of the damping is thus composed of the two characteristics of the two damping volumes 60 and 70.

[0033] Vice-versa if pressure peaks arise in the fluid line B, initially the first piston 52 is displaced towards the second port 46. Since the charging pressure is lower in the first damping volume 60, initially only the first damping volume 60 is compressed. If substantially the same pressure as in the second damping volume 70 prevails in the first damping volume 60, only then is the second piston 54 also displaced towards the second port 46, so that both the first damping volume 60 and the second damping volume 70 are compressed. Accordingly the damping behaviour of the piston accumulator 66 is symmetrical in relation to the two ports 44 and 46.

[0034] A conventional damping arrangement corresponding to Fig. 6, which is formed by conventional hydraulic accumulators, is illustrated in Fig. 7 in the same hydraulic system. The structure of the hydraulic system in this case corresponds to the structure shown in Fig. 1 and is therefore not explained in further detail. In order to produce the damping behaviour made available by the piston accumulator 66 according to the invention, two hydraulic accumulators (or also piston accumulators) in each fluid line A and B must in each case be connected in parallel. One hydraulic accumulator 82 in this case is filled with a charging pressure of 22 bar, while the other hydraulic accumulator 84 connected in parallel to the first hydraulic accumulator 82 is filled with a charging pressure of substantially 35 bar. As a result a damping characteristic, which consists of the two damping characteristics of the individual hydraulic accumulators 82 and 84, is also produced by the four hydraulic accumulators 82, 84 in the two fluid lines A and B respectively. As is evident from the comparative illustration of Fig. 7, a substantially more space-saving arrangement, which is cost-favourable at the same time using the advantages of a piston accumulator, is made available through the piston accumulator 66 according to the invention.

[0035] Fig. 5 illustrates a piston accumulator 86 according to a second embodiment of the present invention. Below, only the differences in relation to the first embodiment are discussed.

[0036] The piston accumulator 86 again comprises a first piston 52, a second piston 54 and a third piston 68, which in each case are contained slidably in the cylinder 42. Again, a first damping volume 60 is formed between the first (52) and the second (54) piston, whose charging pressure in the present exemplary embodiment is adjusted to substantially 22 bar (with un-pressurized ports 44 and 46; that is to say, at substantially 1 bar). Again, a second damping volume 70 is formed between the second (54) and the third (68) piston, whose charging pressure, with un-pressurized ports 44 and 46, amounts to substantially 35 bar. Compared to the first embodiment, in the case of the piston accumulator 86 no displacement limitation device is formed between the second piston 54 and the third piston 68. On the other hand the cylinder 42 comprises a stop 88, which in the present embodiment is formed by an inner circlip provided on the inside of the cylinder 42. The position of the stop is selected in such a way that the charging pressure designated in each case, with un-pressurized ports 44 and 46, prevails in the two damping volumes 60 and 70. Furthermore, it is proposed that the position of the stop can be varied.

[0037] Again, screw plugs 64, which are disposed in orifices, are provided in the first piston 52 and the third piston 68 so that the two damping volumes 60 and 70 can be filled with fluid.

[0038] The functional mode of the piston accumulator 86 is described below, it being assumed that the piston accumulator is included in a hydraulic system, as illustrated in Fig. 6. The arrangement of the piston accumulator 86 in this case is schematically illustrated in Fig. 6

over the piston accumulator 66. Above this, a corresponding arrangement of the piston accumulator 40 of Figure 3 is illustrated by way of example.

[0039] A constant operating pressure of substantially 100 bar is again assumed in the fluid line A. If pressure peaks now arise in the fluid line A due to oscillations, the third piston 68 is displaced towards the first port 44. Since the charging pressure is lower in the first damping volume 60, initially the second piston 54 is also displaced towards the first port 44. The movement of the second piston 54 however is limited by the stop 88. If the second piston 54 has reached the stop 88, damping takes place exclusively via the damping volume 70, in which the charging pressure of 35 bar prevails. Therefore as soon as the second piston 54 contacts the stop 88, hard damping behaviour is produced.

[0040] If the impact of the piston accumulator 86 is reversed, that is to say if pressure peaks arise in the fluid line B, initially the first piston 52 is displaced towards the second port 46 and the first damping volume 60 with the lower charging pressure is compressed. Only when the pressure in the first damping volume 60 is substantially just as high as the pressure in the second damping volume 70, is the second piston 54 also displaced towards the second port 46 and damping is provided by both damping volumes 60 and 70.

[0041] Accordingly, a simple damping characteristic (through the second damping volume 70) is produced substantially at the second port 46 by the piston accumulator 86, while a compound damping characteristic (as a result of the two damping volumes 60 and 70) is made available at the first port 44. Therefore, damping behaviour is achieved, as made available in Fig. 2 by the three conventional piston accumulators 26, 28 and 30. The piston accumulator 30 in Fig. 2 would only have to be filled with a charging pressure of substantially 35 bar.

[0042] Figs. 8A and 8B illustrate a piston accumulator 90 according to a third embodiment of the present invention. Below, only the differences in relation to the accumulator of Figure 3 are discussed.

[0043] The piston accumulator 90 again comprises a cylinder 42 and a port 44, which is provided at the one end of the cylinder 42. The port 44 makes the connection to a fluid system to be damped. The end of the cylinder 42 facing the port 44 is closed. Again, a first piston 52, which is contained in a sealed manner and is slideable in the container 42, is provided. A second piston 54, which is likewise contained in a sealed manner and is slideable in the cylinder 42, is provided between the first piston 52 and the closed end of the cylinder 42.

[0044] An active volume, which can be increased depending upon pressure in the connected fluid system by displacing the first piston 52 towards the closed end of the cylinder 42, is formed in the cylinder 42 between the first screw plug 48, in which the port 44 is provided, and the first piston 52. A first damping volume 92, which is filled with fluid at least during use, is formed between the first piston 52 and the second piston 54. A second damping volume 94, which is filled with fluid at least during use, is formed between the second piston 54 and the closed end of the cylinder 42.

[0045] In the same way as has already been explained with reference to Figs. 4A and 4B, it is preferable if a higher charging pressure (for example 35 bar in relation to atmosphere) prevails in the second damping volume 94 than in the first damping volume 92 (for example 22 bar in relation to atmosphere). Thus, the advantages of a compound damping characteristic can be realized. In order to prevent equal pressure between the first 92 and the second 94 damping volumes, a displacement limitation device 72 is provided between the second piston 54 and the closed end of the cylinder 42. This is constructed similarly to the displacement limitation device 72 illustrated in Figs, 4A and 4B, so that a detailed explanation is omitted.

[0046] The present invention is not restricted to the embodiments illustrated in the figures. In particular, the connection of the two ports 44 and 46 to the two fluid lines A and B can also be interchanged. Furthermore, the pressure ratio in the two damping volumes 60 and 70 can also be interchanged. The provision of a stop 88, as explained in Fig. 5, can be made at another position or even on the other side of the second piston 54. Also, the movement of the first piston 52 and/or the third piston 68 can be limited in each case by a stop and therefore a designated damping characteristic can be produced. Furthermore, provision can be made for a displacement limitation device, as illustrated for example in Figs. 4A to 4C, to be formed between the first and the second piston.

[0047] The screw plugs 48 and 50 can, of course, also be incorporated with the cylinder 42. Also, the ports 44 and 46 may be provided integrally in this arrangement. Furthermore, it is not absolutely essential that the cylinder 42 and the pistons 52, 54 and 68 each have a round cross section.

Claims

1. Piston accumulator for damping two fluid systems (A, B), comprising:

    a cylinder (42);
    a first port (44) for a fluid system (B) to be damped, which is disposed at one end of the cylinder (42); and
    a first piston (52), which is contained in a sealed manner and slidably in the cylinder (42);
    a second port (46) for a second fluid system (A) to be damped, which is disposed at the other end of the cylinder (42); and
    at least one second piston (54), which is contained in the cylinder (42) in a sealed manner and is slideable between the first piston (52) and the second port (46), wherein a first damping volume (60), formed between the first (52) and

the second (54) piston, is or can be filled with fluid,

characterized by a third piston (68), which is contained in the cylinder (42) in a sealed manner and is slideable between the second piston (54) and the second port (46), wherein a second damping volume (70), formed between the second (54) and the third (68) piston, is or can be filled with fluid.

2. Piston accumulator according to Claim 1, **characterized in that** the first and second pistons (52, 54) have the same diameter.

3. Piston accumulator according to Claim 1 or 2, **characterized in that** the cylinder (42) is closed on both sides in each case by a plug, preferably a screw plug (48, 50), wherein a port (44, 46) is disposed in each plug respectively.

4. Piston accumulator according to any preceding claim, **characterized in that** the second piston (54) and the third piston (68) are coupled together via a displacement limitation device (72), by means of which a maximum relative displacement between the second (54) and the third (68) piston is defined, wherein the maximum relative displacement is preferably adjustable.

5. Piston accumulator according to Claim 4, **characterized in that** the displacement limitation device (72) comprises a guide (74) connected to one of the second (54) and the third piston (68) and a guide device (76) connected to the other of the second (54) and the third piston (68), wherein the guide device (76) can be moved in the guide (74) along the displacement direction of the pistons (52, 54, 68) over the length of the maximum relative displacement.

6. Piston accumulator according to any preceding claim, **characterized in that** the movement of the second (54) and/or the third (68) piston along the displacement direction of the pistons (52, 54, 68) is limited by a stop (88), wherein the position of the stop (88) is preferably variable.

7. Piston accumulator according to any one of Claims 4 to 6, **characterized in that** the first (60) and the second damping volume (70) in each case are filled with gas, wherein with un-pressurized ports (44, 46), the pressure in the first damping volume (60) is lower than the pressure in the second damping volume (70).

8. Piston accumulator according to Claim 7, **characterized in that** with the un-pressurized first (44) and second (46) port, the pressure in the first damping volume (60) lies in a range of substantially 18 to 26 bar, preferably in a range of substantially 20 to 24 bar, and **in that** the pressure in the second damping volume (70) lies in a range of substantially 31 to 39 bar, preferably in a range of substantially 33 to 37 bar.

9. Piston accumulator according to any one of the preceding claims, **characterized in that** at least one of the pistons (52, 54, 68) comprises an orifice, which can be closed by a plug, preferably a screw plug (64), through which a damping volume (60, 70) adjacent to the respective pistons (52, 54, 68) can be filled with gas.

10. Piston accumulator for damping a fluid system, comprising:

a cylinder (42);

a port (44) for the fluid system to be damped, which is disposed at one end of the cylinder (42), wherein the end, facing the port (44), of the cylinder (42) is closed; and

a first piston (52), which is contained in a sealed manner and slidably in the cylinder (42); **characterized by**

at least one second piston (54), which is contained in the cylinder (42) in a sealed manner and slidably between the first piston (52) and the closed end of the cylinder (42), wherein a first damping volume (92), formed between the first (52) and the second (54) piston, is or can be filled with fluid and wherein a second damping volume (94), formed between the second piston (54) and the closed end of the cylinder (42), is filled or can be filled with fluid.

11. Damped hydraulic system, **characterized by** a hydraulic cylinder (2; 4) with a first (8) and a second (10) piston chamber, which can be impacted in each case with fluid pressure for adjusting the hydraulic cylinder (2; 4), and a piston accumulator (40; 66; 86) according to any one of Claims 1 to 9, wherein the first piston chamber (8) is or can be brought into fluidic communication with the first port (44) of the piston accumulator (40; 66; 86), and wherein the second piston chamber (10) is or can be brought into fluidic communication with the second port (46) of the piston accumulator (40; 66; 86).

12. Utility vehicle, in particular an agricultural vehicle, which comprises an extension arm, preferably a front loader, at least one hydraulic cylinder (2, 4) for raising and lowering the extension arm and a piston accumulator (40; 66; 86) according to any one of Claims 1 to 9, wherein the hydraulic cylinder (2, 4) comprises a first (8) and a second (10) piston chamber, which in each case can be impacted with fluid pressure for adjusting the hydraulic cylinder (2, 4), wherein the first piston chamber (8) is or can be brought into fluidic communication with the first port (44) of the piston accumulator (40; 66; 86), and wherein the second piston chamber (10) is or can be brought into fluidic communication with the second port (46) of the piston accumulator (40; 66; 86).

13. Utility vehicle according to Claim 12, **characterized by** two hydraulic cylinders (2, 4) connected in parallel for raising and lowering the extension arm and a common piston accumulator (40; 66; 86), wherein the hydraulic cylinders (2, 4) each have a first (8) and a second (10) piston chamber, wherein the first piston chambers (8) are or can be brought into fluidic communication with the first port (44) of the piston accumulator (40; 66; 86), and wherein the second piston chambers (10) are or can be brought into fluidic communication with the second port (46) of the piston accumulator (40; 66; 86).

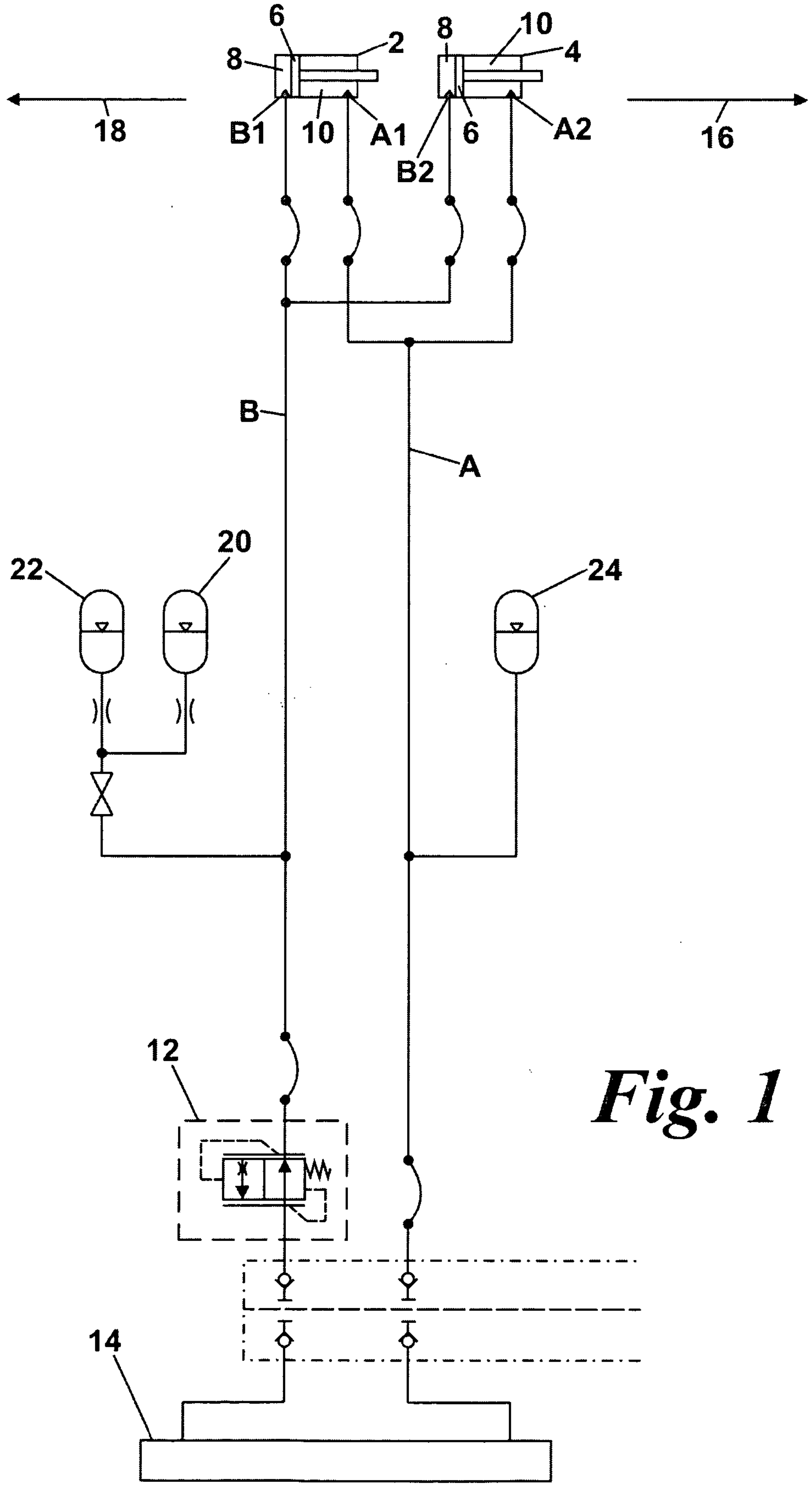

Fig. 1

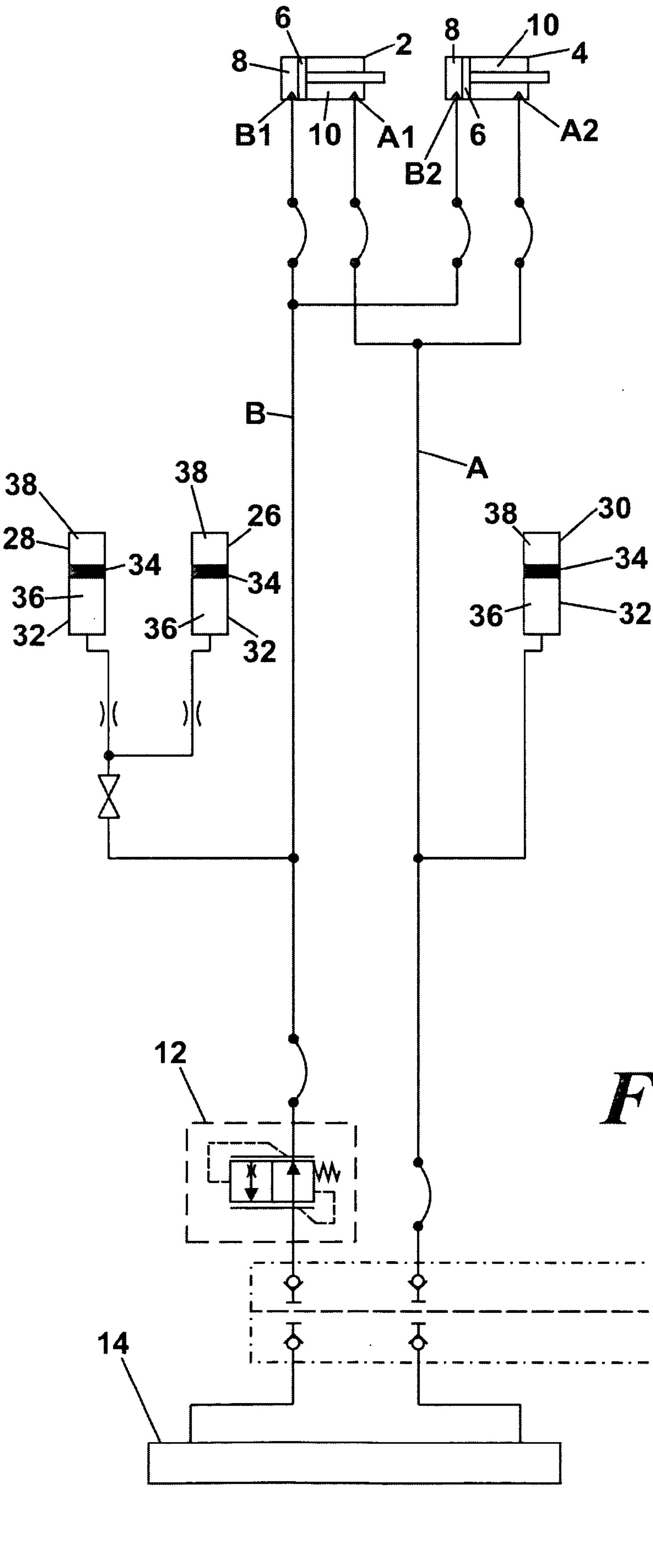
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Fig. 2

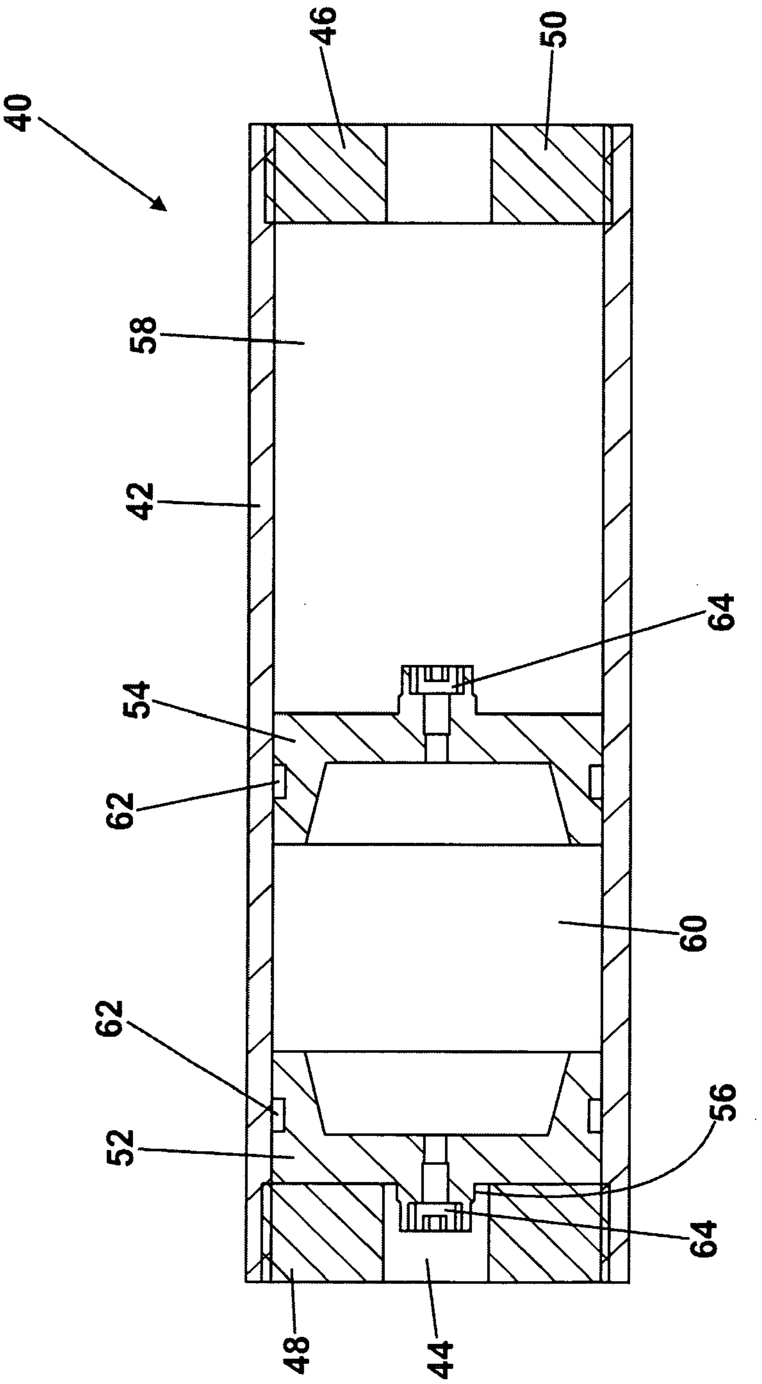
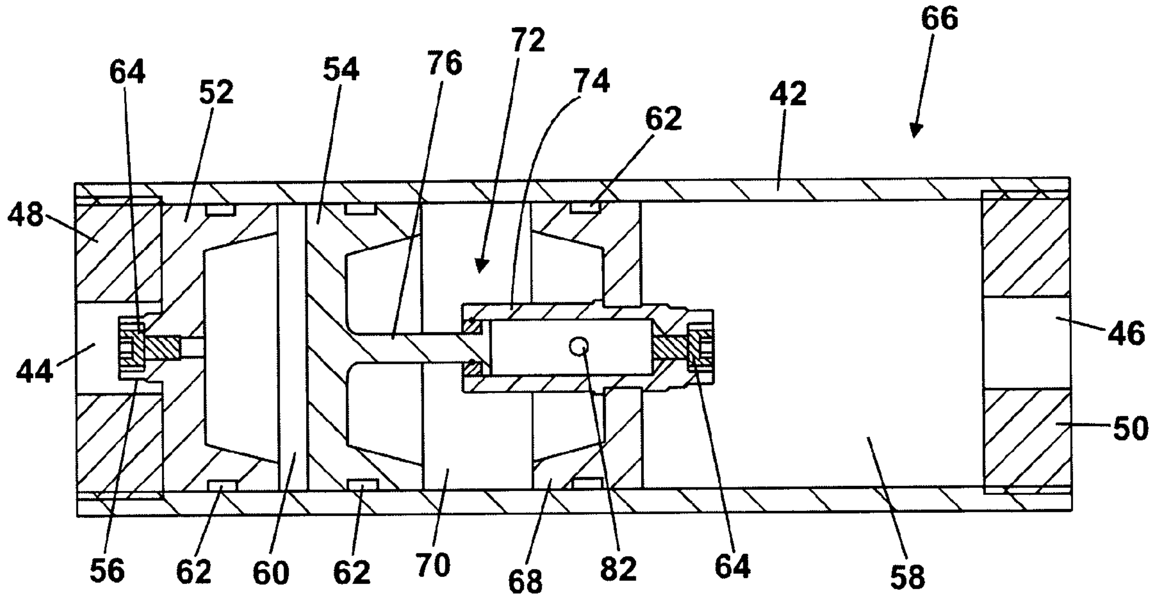


Fig. 3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64
58

Fig. 4A

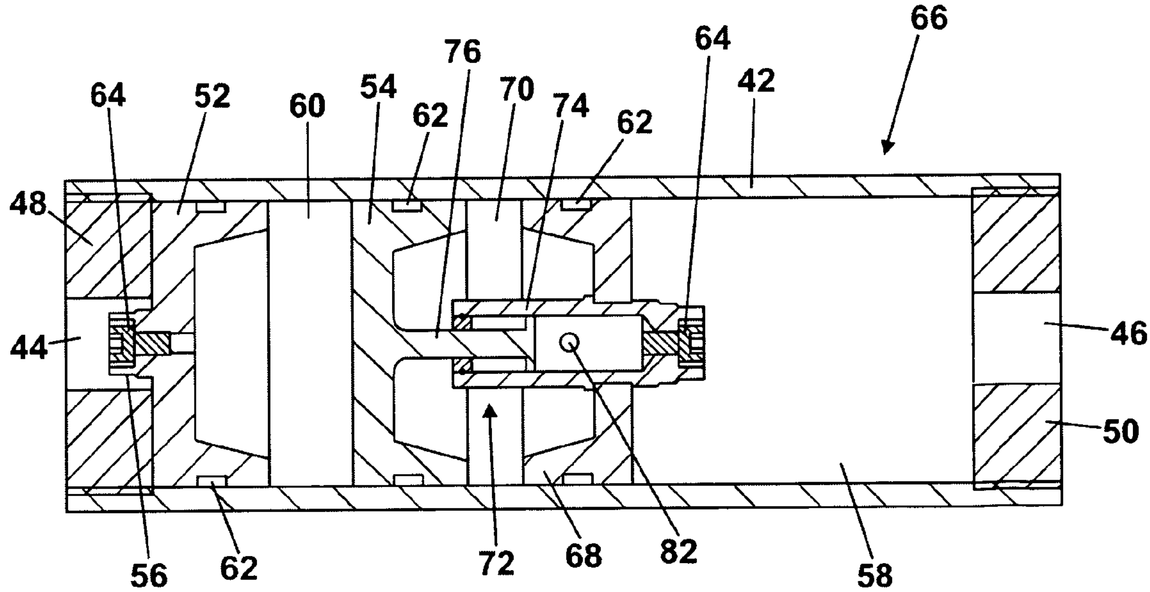
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Fig. 4B

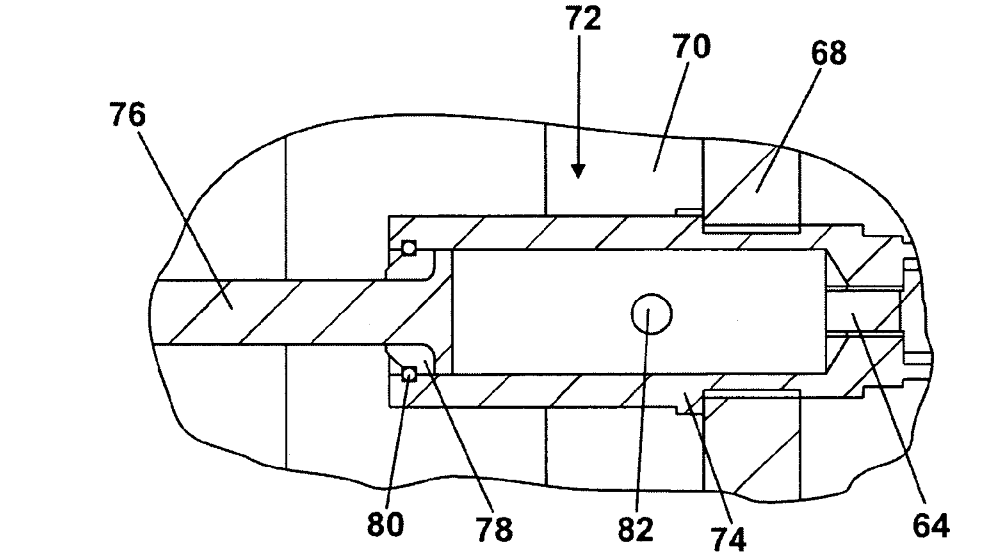
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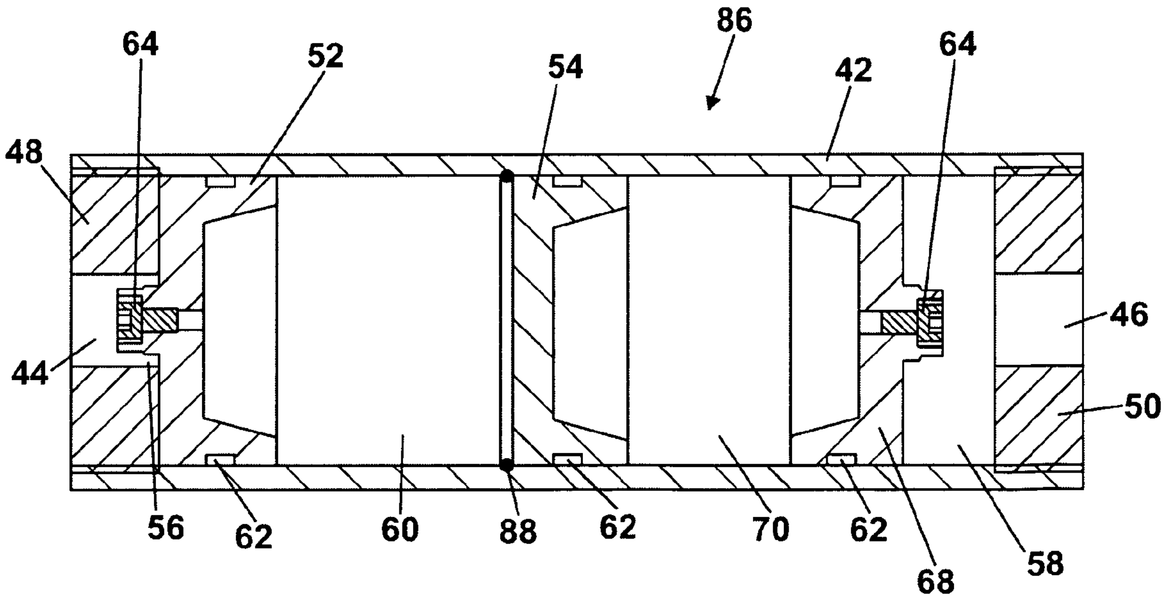
Fig. 4C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70
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68
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Fig. 5

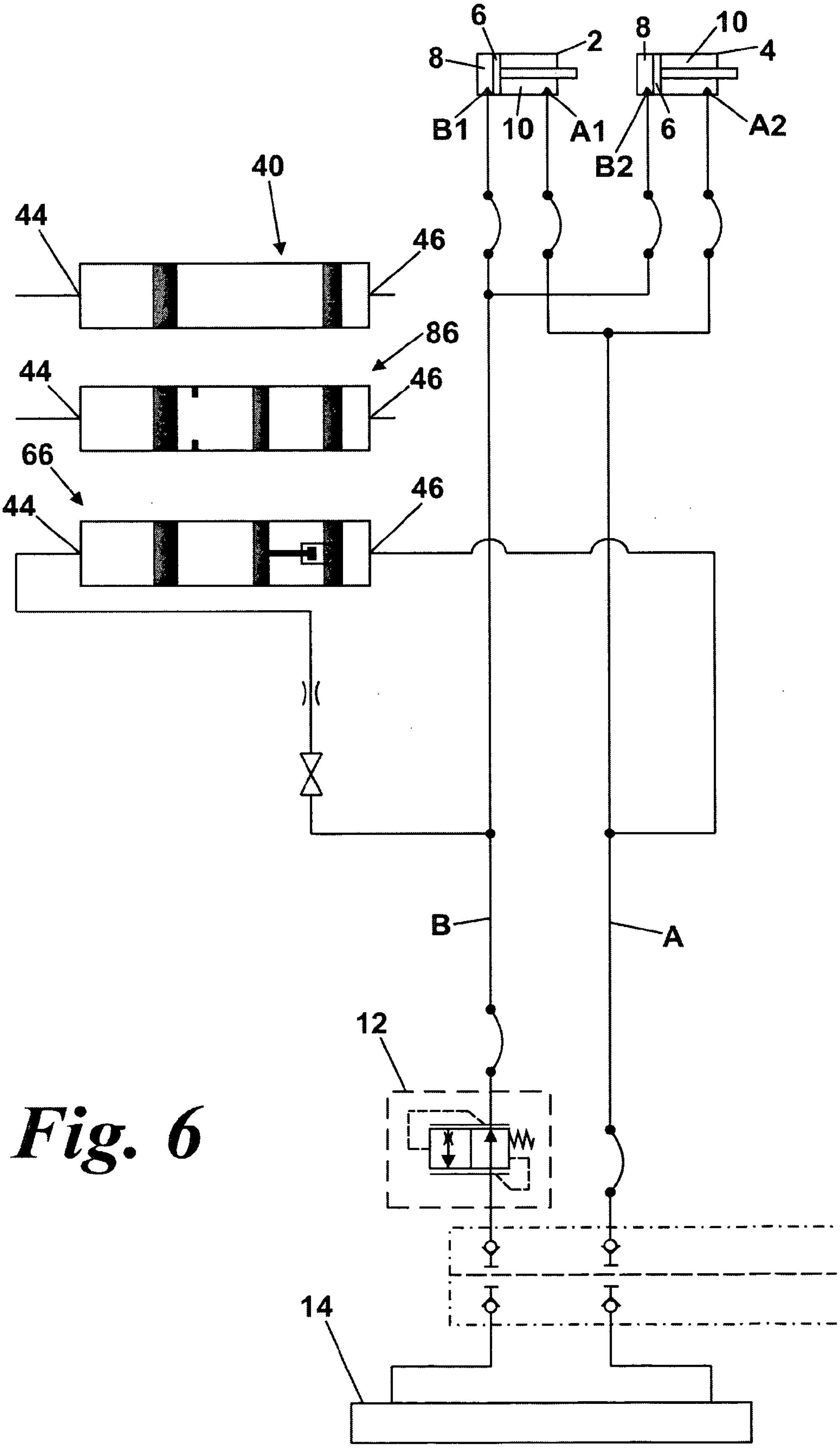

Fig. 6

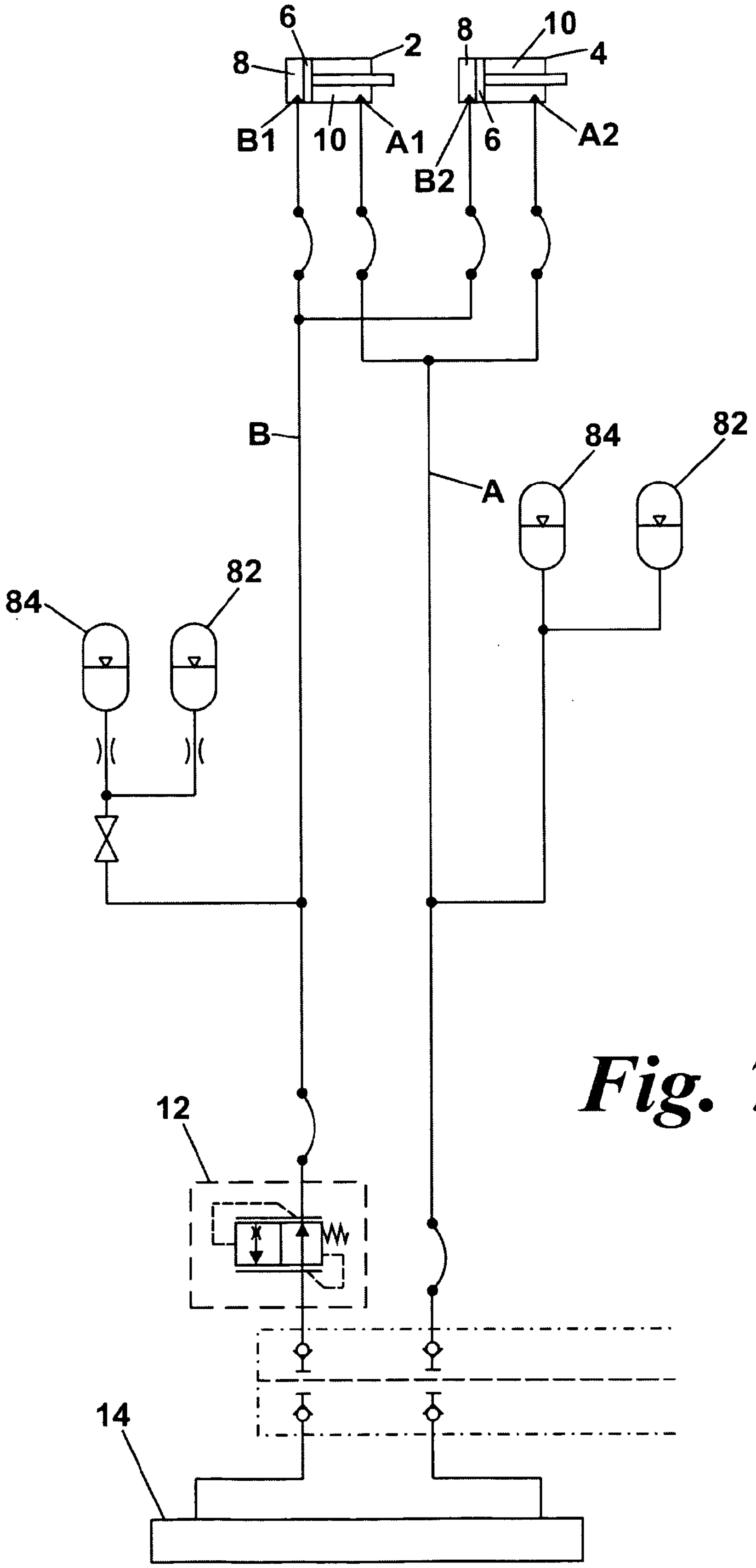

Fig. 7

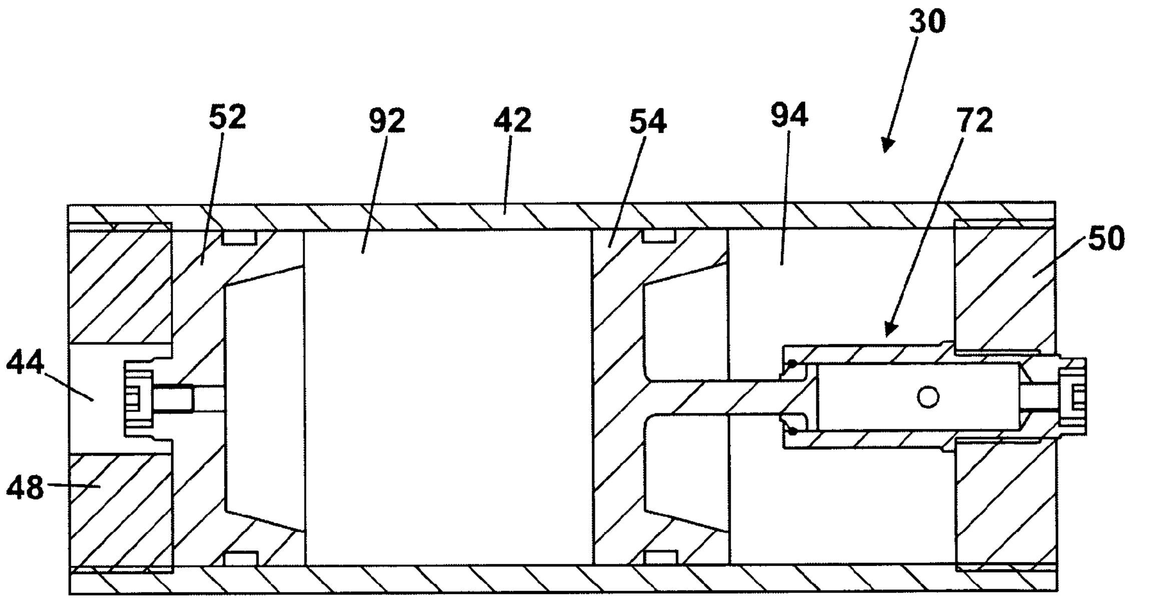

Fig. 8A

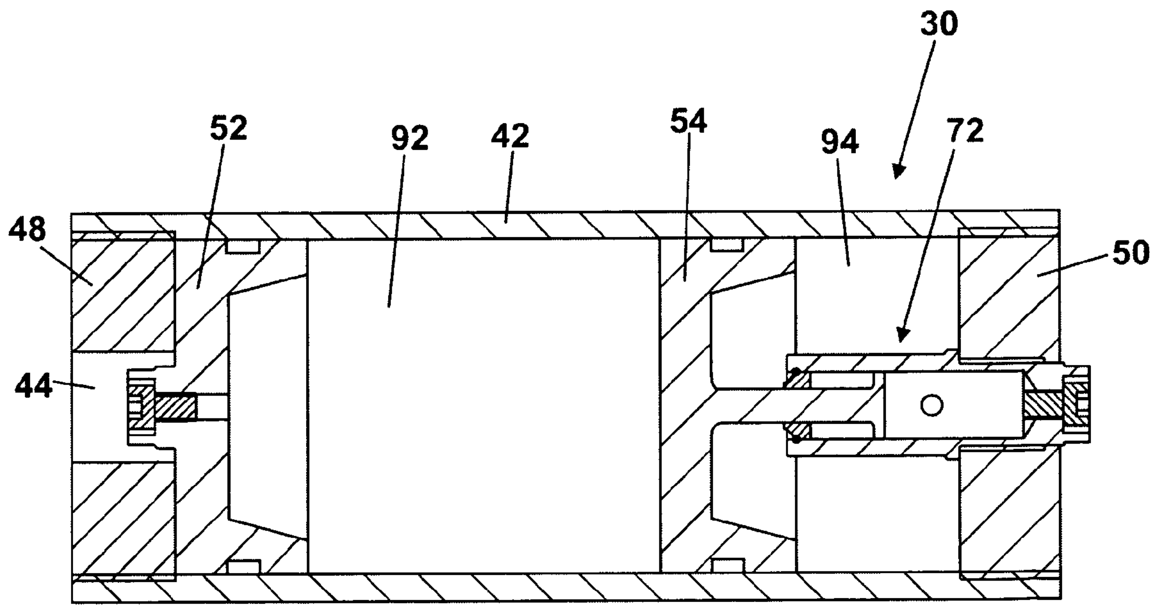

Fig. 8B

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

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