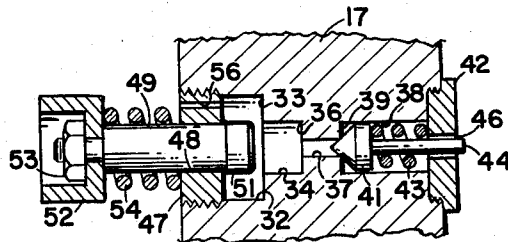
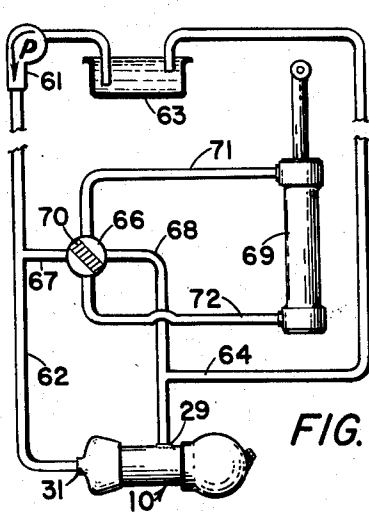
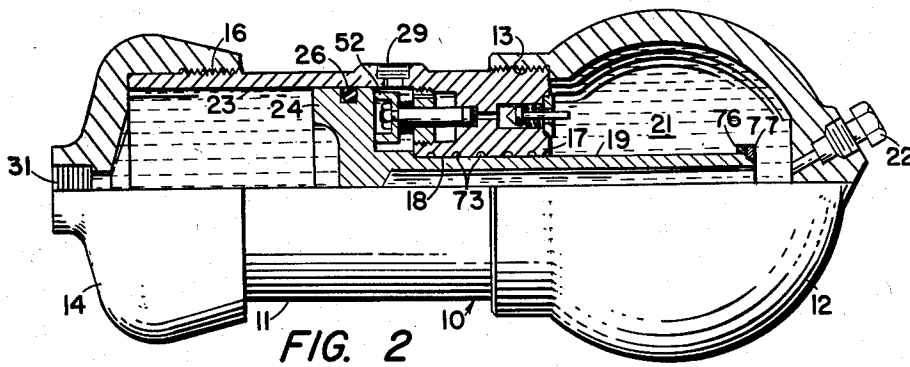
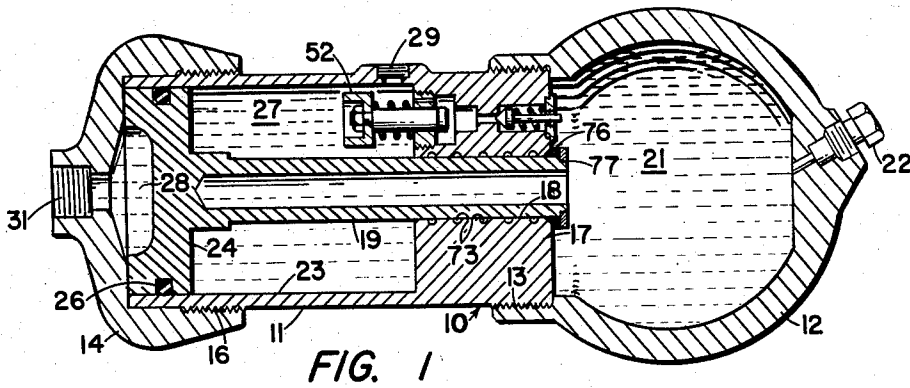


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W. B. WESTCOTT, JR
LIQUID SPRING ACCUMULATOR

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LIQUID SPRING ACCUMULATOR

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This invention relates generally to accumulators and more particularly to an accumulator which utilizes a liquid spring to maintain the accumulator pressure and includes means to automatically maintain proper pressure in the liquid spring.

It is an important object of this invention to provide an accumulator utilizing a liquid spring to maintain accumulator pressure.

It is another important object to provide a liquid spring pressurized accumulator wherein the liquid of the spring is the same liquid as the liquid stored within the accumulator.

It is another object of this invention to provide an accumulator which is explosion proof.

It is still another object of this invention to provide a compact accumulator pressurized by a liquid spring including means to automatically maintain the liquid pressure of the spring.

It is still another object of this invention to provide an accumulator wherein the operation of the accumulator automatically charges the spring used to pressurize the device.

It is still another object of this invention to provide an accumulator having a storage chamber in which reservoir return liquid can be stored.

Further objects and advantages will appear from the following description and drawings, wherein:

Figure 1 is a side elevation in longitudinal section of a preferred form of an accumulator according to this invention showing the elements when the plunger is extended;

Figure 2 is a view similar to Figure 1 showing the position the elements assume when the pumping mechanism is operating to add liquid to the liquid spring;

Figure 3 is an enlarged fragmentary longitudinal section showing the structural details of the automatic pumping mechanism; and

Figure 4 is a schematic illustration of a hydraulic system to which the accumulator according to this invention is particularly suited.

In hydraulic systems, accumulators are used to provide for the storage of liquid under pressure which liquid is available for use in operating the system's fluid motors or the like. Accumulators are particularly advantageous when the fluid motor of the system is intermittently operated since they permit the system pump to build up a supply of liquid under pressure over a period of time which liquid under pressure can be used quickly to operate fluid motors. This permits the use of smaller pumps and power sources for a given system and also provides an advantage in permitting the use of smaller pressure lines if the accumulators are located adjacent to the fluid motor.

Referring to the drawings, a preferred form of accumulator according to this invention is provided with a body assembly 10 which includes a tubular main accumulator housing 11, a hollow spherical spring housing 12 threaded onto one end of the main accumulator housing

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11 at 13, and an end member 14 threaded onto the other end of the main accumulator housing 12 at 16. The main accumulator housing 11 is formed with an end wall 17 having a central aperture or bore 18 through which a plunger 19 projects. The end wall 17 co-operates with the plunger 19 and spring housing 12 to define a spring chamber 21 the volume of which is reduced by movement of the plunger 19 to the right as viewed in the drawings and the volume of which is increased by movement of the plunger 19 to the left. The spring chamber 21 is completely filled with liquid at a precharge pressure when the plunger 19 is in the extended or left-hand extreme position shown in Figure 1 which liquid is compressed by movement of the plunger toward the compressed position of Figure 2. A removable plug 22 is threaded into the spring housing 12 to permit filling of the spring chamber 21 and/or bleeding of air therefrom. Once the spring chamber 21 is filled, the plug 22 is tightened to close the spring chamber.

The main accumulator housing 11 is formed with an axially extending bore 23 which defines an accumulator cavity into which the plunger 19 projects. A piston head 24 formed on the left end of the plunger 19 extends into engagement with the wall of the bore 23 and is provided with an O-ring seal 26 to prevent leakage along the wall of the bore 23 past the piston head 24. Therefore, the end wall 17, the bore 23, and the piston 24 co-operate to define a reservoir chamber 27 on the side of the end wall 17 opposite the spring chamber 21. An accumulator chamber 28 is defined by the piston head 24, the end member 14, and the wall of the bore 23 on the side of the piston head opposite the reservoir chamber 27. When the plunger 19 is in the left-hand or extended position of Figure 1, the reservoir chamber 27 is at maximum volume and the accumulator chamber 28 is at minimum volume. However, movement of the plunger 19 and the piston head 24 to the right toward its compressed position reduces the volume of the reservoir chamber 27 and increases the volume of the accumulator chamber 28. The total volume of the two chambers 27 and 28, however, is substantially constant and is only changed by the displacement of the plunger 19 within the reservoir chamber 27. To provide a connection between the reservoir chamber 27 and the connected system, the main housing 11 is provided with a threaded port 29 to which a pressure line can be connected. The accumulator chamber 28 can similarly be connected to a pressure line of the pressure system by threading a pressure line into a threaded port 31 in the end member 14.

In order to insure that the spring chamber 21 is always filled with the proper amount of liquid under pressure, I provide an automatic replenishing pump best illustrated in Figure 3. The end wall 17 is formed with a bore 32 extending from the left side thereof and terminating in a shoulder 33. A smaller diameter cylinder bore 34 coaxial with the bore 32 extends beyond the bore 32 and terminates a second shoulder 36. A still smaller diameter connecting bore 37 extends beyond the cylinder bore 34 and opens into a check valve bore 38. The diameter of the check valve bore is larger than the diameter of the connecting bore so a third shoulder 39 is provided at the junction of these two bores which is utilized as the valve seat for a check valve member 41. A spring retainer 42 is threaded into the end wall 17 and provides a retaining surface for a check valve spring 43 which operates to urge the check valve member against the shoulder 39 to maintain the check valve in a normally closed position. The check valve member is also formed with a stem 44 which projects through the spring 43 and loosely fits through an aperture 46 formed in the spring retainer 42.

The outer end of the bore 32 is threaded to receive a support ring 47 formed with a central aperture 48 through

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which projects a piston 49 having a piston head 51. A cup-shaped spring retainer 52 is mounted on the left end of the piston 49 by a threaded fastener 53 and a spring 54 extends between the spring retainer 52 and the support ring 47 and resiliently urges the piston to the left to the position shown in Figure 3. The piston head 51 is proportioned to closely fit the cylinder bore 34 when it moves to the right from the position in Figure 3 but is proportioned to move completely out of the cylinder bore 34 at the left extreme of its travel. A side port 56 extends through the support ring 47 to provide fluid communication between the reservoir chamber 27 and the bores 32 and 34 so that these bores will always be filled with liquid from the reservoir chamber 27.

Normally, the actuator would be used in a system of a general type shown in Figure 4 wherein the output of a pump 61 is connected to a port 31 through a pressure line 62 and the port 29 is connected to a reservoir 63 through a reservoir return line 64. A four-way valve 66 is connected to the pressure line 62 by a branch line 67 and to the reservoir return line 64 through a branch line 68. The four-way valve 66 is also connected to a fluid motor 69, represented in the illustrated case as a piston and cylinder type, through controlled pressure lines 71 and 72. When the valve element 70 of the four-way valve is in the position schematically shown, fluid under pressure from the pump 61 and from the accumulator port 31 is supplied to the lower end of the cylinder 69 and the upper end of the cylinder 69 is connected to the accumulator port 29 and to the reservoir 63. Rotation of the valve element 70 of the four-way valve 66, of course, can reverse the cylinder connections in the usual manner.

In operation, the pump 61 operates to supply pressure fluid through the pressure line 62 and the accumulator port 31 to the accumulator chamber 28. The pressure of the liquid in the chamber 28 produces a force reaction on the piston head 24 and in turn on the plunger 19 which urges the plunger 19 to the right from the position shown in Figure 1 thus compressing the liquid within the spring chamber 21. The effective area of the plunger 19 is substantially less than the effective area of the piston head 24 so a given pressure within the accumulator chamber 28 will produce a much higher pressure within the spring chamber 21. As the system pressure builds up, the plunger 19 continuously moves to a position of equilibrium wherein the force reaction of the compressed liquid in the spring chamber 21 balances the force created by the pressure in the chamber 28 on the piston head. The various elements are proportioned and the device is designed so that the plunger 19 moves to a position wherein the piston head 24 is adjacent to the spring retainer 52 when maximum normal system pressure is reached. However, if there has been any leakage out of the spring chamber 21, the pressure forces on the plunger 19 and piston head 24 will not be balanced when this position is reached. If such is the case, the pump mechanism shown in Figure 3 automatically operates to supply additional liquid to the spring chamber.

The pump mechanism operates whenever the pressure within the spring chamber 21 is not sufficiently high to maintain the piston head 24 in a position wherein the pump is not operated by the piston head 24. When the spring chamber 21 does not contain sufficient pressure, the system line pressure in the chamber 28 causes the piston head to move to the right to the position shown in Figure 2. This causes the piston head 51 of the piston 49 to enter the cylinder bore 34 thus trapping liquid contained therein and elevating its pressure sufficiently high to pump a charge of liquid past the check valve member 41 into the spring chamber. This charge of liquid, of course, raises the pressure of the spring chamber. The normal operation of the pump 61 is cycled by the usual on-off pressure switch, not shown, and this cycling plus the operation of the fluid motor 69 causes cycling of the pressure within the system and within the accumulator chamber 28. This in turn causes the piston

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head 24 to move back and forth in a cyclic manner. Each time the pressure is raised to maximum system line pressure within the accumulator chamber 28, an additional charge will be pumped into the spring chamber 21 if the pressure already present is not at the proper pressure. Therefore, the piston 49 continues to supply an added charge of liquid to the spring chamber 21 each time the pressure in the system cycles until the pressure in the spring chamber 21 reaches a pressure which will prevent the piston head 24 from moving sufficiently far to actuate the pump. Thus, as soon as the proper pressure is present, the pump mechanism automatically becomes inoperative but if the pressure within the spring chamber drops for any reason, the pump mechanism automatically starts operating to re-establish the proper spring pressure.

Because the accumulator automatically pumps itself up, it is possible to use a metal to metal seal between the surface of the bore 18 and the plunger 19. Such type seals are improved by cutting a plurality of annular grooves 73 in the surface of the bore 18 so that very small amounts of leakage will pass. This is advantageous since it prevents excessive pressures from building up due to temperature increases of the liquid in the spring and does not create difficulties because the pump mechanism is sized to replenish any leakage out of the spring chamber 21. Whenever the system to which the accumulator is connected is shut off, the pressure in the accumulator chamber 28 goes to zero before the pressure in the spring chamber 21 drops so that the plunger 19 will be in the extended position whenever the system is re-pressured. At this time, a relatively soft packing seal 76 on the plunger 19 is seated between a flange 77 on the plunger 19 and the face of the end wall 17, as shown in Figure 1, to provide a complete seal against leakage out of the spring chamber 21.

An accumulator according to this invention is much more compact since a smaller volume of liquid within the spring chamber 21 can be provided for a given volume change in the accumulator chamber 28 within a given pressure range. This is due to the fact that a liquid spring has a relatively straight compression curve when compared with compressed air spring and the like. In addition, a small volume of liquid is capable of absorbing large amounts of energy. Also, since the reservoir return line 64 is connected to the reservoir chamber 27, the exhaust of the fluid motor 69 can flow into the reservoir chamber 27 as it increases in volume due to flow of liquid out of the accumulator chamber 28. Therefore, the accumulator provides for storage of reservoir liquid and reduces the necessary size of the remote reservoir 63. Also, because all of the dynamic seals are internal, any leakage out of the spring chamber 21 is returned to the system.

An accumulator according to this invention also has the advantage of not having highly compressed gases contained therein so if the accumulator is damaged, there is no danger of explosions. This is due to the fact that although liquid is compressible, the degree of compression is very small and a fracture in the spring housing 12 will relieve the pressure in the spring chamber so quickly that fragmentation type explosions do not occur.

Although a preferred embodiment of this invention is illustrated, it will be realized that various modifications of the structural details may be made without departing from the mode of operation and the essence of the invention. Therefore, except insofar as they are claimed in the appended claims, structural details may be varied widely without modifying the mode of operation. Accordingly, the appended claims and not the aforesaid detailed description are determinative of the scope of the invention.

I claim:

1. An accumulator comprising a hollow body, a partition in said body dividing it into a spring chamber and

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an accumulator cavity, a movable plunger extending through said partition, a head on said plunger in said cavity dividing it into an accumulator chamber and a reservoir chamber, liquid filling said chambers, and a pump in said partition connecting said reservoir chamber and spring chamber, said head engaging and operating said pump to transfer liquid from said reservoir chamber to said spring chamber upon movement of said plunger to a predetermined position.

2. An accumulator for use in a hydraulic system the pressure of which is intermittent comprising a hollow body, a partition in said body dividing it into a spring chamber and an accumulator cavity, a plunger slidable through said partition with a close fit to provide a seal therewith permitting a small rate of leakage, a head on said plunger in said accumulator cavity engaging said body, said head dividing said accumulator cavity into an accumulator chamber and a reservoir chamber the volumes of which are changed by movement of said head and plunger relative to said body, compressed liquid

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completely filling said spring chamber producing a force on said plunger urging it in a direction toward an extended position tending to reduce the volume of said accumulator chamber and increase the volume of said reservoir chamber, a fluid tight seal between said plunger and partition operative only when said plunger is in said extended position to prevent any leakage out of said spring chamber, and a pump connected to said spring chamber operative to pump liquid into said spring chamber upon movement of said plunger to a predetermined position relative to said body.

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