

[54] **HYDRAULIC SYSTEM ACCUMULATOR
ARRANGEMENT**

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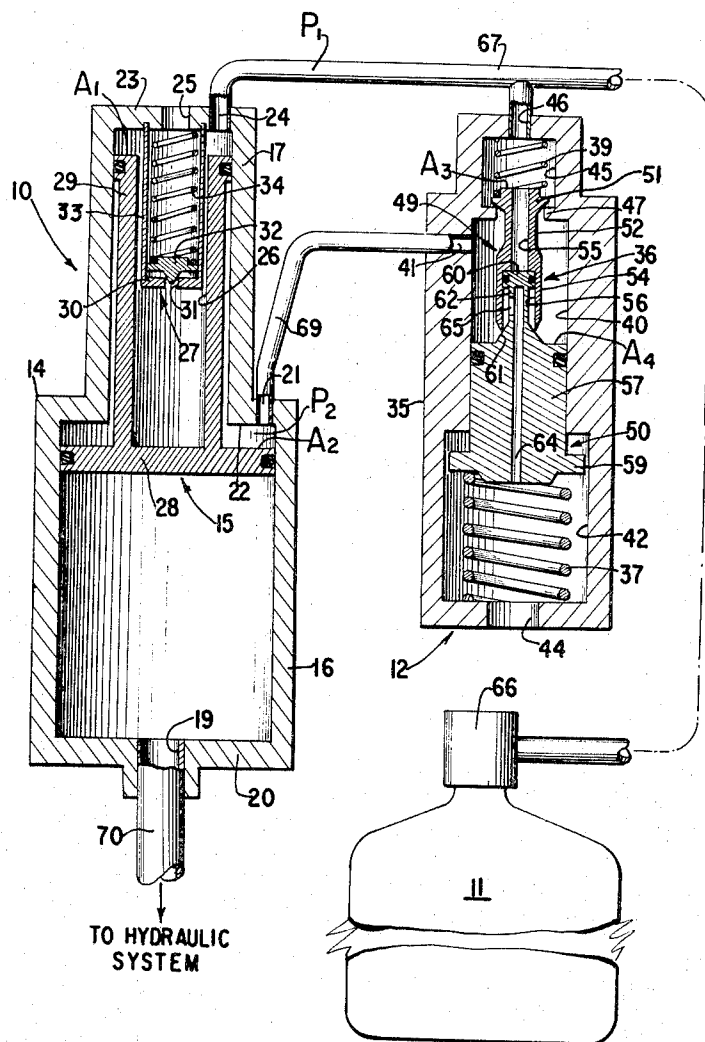
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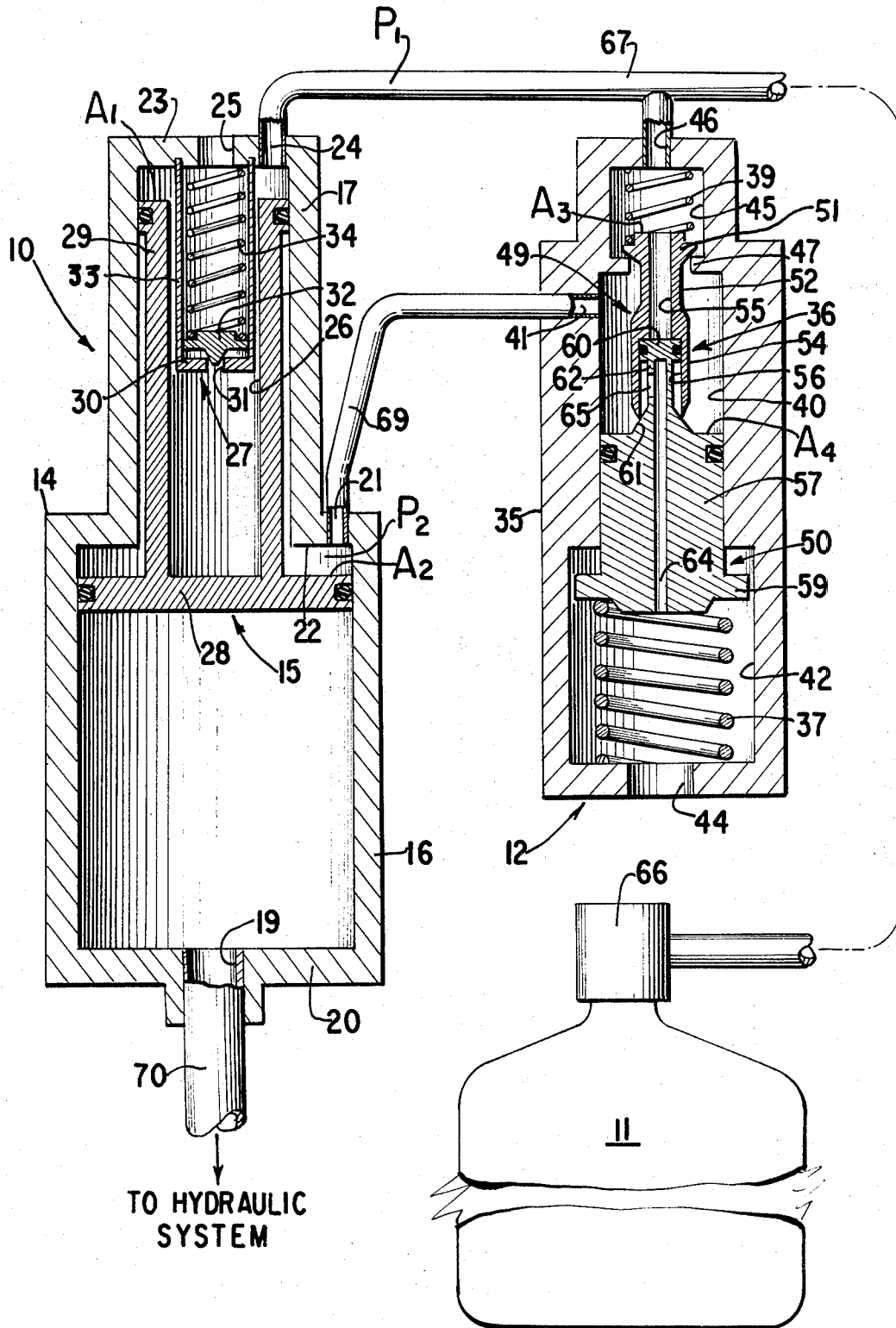
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[57] **ABSTRACT**

An accumulator arrangement for providing constant pressure high flow rates in hydraulic systems. The accumulator piston has a piston area directly connected to a container of pressurized gas and an annular piston area of larger diameter which is connected to the container through a pressure regulator. The regulator senses the container pressure and the pressure acting on the annular piston area and increases the pressure on the annular piston area as the container pressure decreases during expansion. Between high flow periods, when the accumulator is refilled by hydraulic fluid under pressure, the gas acting on the small diameter piston is recompressed and forced back into the container and the gas acting on the annular piston area is vented to the atmosphere through the regulator.

9 Claims, 1 Drawing Figure





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HYDRAULIC SYSTEM ACCUMULATOR ARRANGEMENT

BACKGROUND OF THE INVENTION

The present invention relates to accumulators, and, more particularly, to accumulators which employ a source of pressurized gas to maintain the hydraulic fluid at a constant pressure as it is being expelled from the accumulator.

In vehicles, particularly air borne vehicles such as aircraft, missiles and space craft, hydraulic systems are frequently used to provide the motive power for the operation of a wide variety of apparatus on board. It is extremely common that during the greater portion of a trip or flight the volume of hydraulic fluid necessary to power apparatus in use is quite low and, during certain periods, a high flow of fluid is required to power additional apparatus. It is common practice to provide a hydraulic pump which produces, at least during a portion of the trip, a flow rate slightly higher than that required. The excess flow is then stored in an accumulator to be available during the peak demand periods.

In the past, systems using a combined pump and accumulator have been of two general types. One type, which is referred to as a closed system type, employs an accumulator in which the excess flow of fluid moves a piston or a bladder against a trapped volume of gas. As the fluid fills the accumulator, the gas is compressed until it is at the output pressure of the pump. After this point is reached, the excess flow is bled back to the pump inlet through a pressure operated valve, or, in systems using a pressure compensated pump, the displacement of the pump is automatically decreased so that the flow provided by the pump matches the demand of the system. In this system, during the high flow periods, the pressure of the fluid delivered by the accumulator drops off rapidly unless a very large accumulator is employed.

The other type of system, referred to as a blow down system, employs in addition to the accumulator a bottle of high pressure gas which is connected to the gas volume in the accumulator through a pressure regulator. The pressure in the bottle is much higher than the required hydraulic pressure and is reduced to the required pressure by the regulator. When high flow is required, gas is introduced into the accumulator and expels the hydraulic fluid at the desired pressure. Between peak demand periods the pump refills the accumulator, however, since the bottle pressure is higher than the pump output pressure, the gas in the accumulator cannot be pumped back into the bottle and must be dumped into the atmosphere. The pressure in the hydraulic system must be maintained at all times, therefore, the pump must compress the gas to bring its pressure somewhat above the required hydraulic pressure before it can be dumped. Since none of the gas which flows into the accumulator can be reclaimed, the work done by the pump in refilling the accumulator is lost and the bottle must contain the entire gas volume required by the accumulator to provide all of the peak flow periods during the trip or flight.

SUMMARY

Accordingly, it is an object of the present invention to provide a highly efficient accumulator arrangement of minimum size and weight which supplies constant pressure hydraulic fluid.

Another object is to provide such an arrangement wherein a source of pressurized gas is used to expell the fluid during periods of high flow demand and a substantial portion of the gas is recompressed during periods of low fluid flow demand.

The foregoing objects are accomplished by providing in a hydraulic system the combination of an accumulator including a volume for storing hydraulic fluid under pressure, a piston in the accumulator for expelling the stored fluid which has first and second piston areas to be acted upon by pressurized gas, a limited supply of pressurized gas for acting on the piston areas, and a pressure regulator for controlling the pressure acting on the second piston area to maintain the fluid in the volume at constant pressure during expulsion.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention has been chosen for purposes of illustration and description, and is shown in the accompanying drawings, forming a part of the specification, wherein:

The single FIGURE of the drawing is a schematic diagram of an accumulator arrangement embodying the present invention in which the accumulator and pressure regulator are shown in longitudinal section.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing in detail there is shown an accumulator arrangement in accordance with the present invention which comprises an accumulator 10, a container of pressurized gas 11, and a pressure regulator 12.

The accumulator 10 includes a casing 14 and a piston 15. The casing is formed with a large diameter cylinder 16 for storing hydraulic fluid and a co-axial small diameter cylinder 17 for receiving gas under pressure to drive the piston. The cylinder 16 is provided with a hydraulic fluid port 19 in its left end wall 20 (as viewed in the drawing) and a gas port 21 in its right end wall 22. The cylinder 17 is provided with a gas port 24 and a vent port 25 in its right end wall 23. The piston 15 is formed with a large diameter section 28 positioned within the cylinder 16 and a small diameter section 29 positioned within the cylinder 17. The piston section 29 is provided with an axial bore 26 to accommodate a pressure relief valve 27 which normally seals the vent port 25.

The relief valve 27 includes a casing having an annular side wall 33 seated in the cylinder wall 26 and an end wall 30 provided with a port 31. Within the casing, a valve member 32 is held in sealing relationship with the port 31 by a spring 34.

The pressure regulator 12 includes a casing 35, a valving assembly 36, and two springs 37 and 39. The casing 35 is formed with a central bore 40 provided with a gas port 41, a left end bore 42 of larger diameter provided with a vent port 44, and a right end bore 45 provided with a gas inlet port 46. An annular valve seat 47 is provided at the junction of the bores 40 and 45.

The valving assembly 36 includes a valve member element 49 and a piston element 50. The element 49 includes a head section 51 within the bore 45 for cooperating with the valve seat 47, a central section 52 of small diameter, and a left end section 54 of larger diameter than the section 52. A bore 55 extends through the head section 51 and the central section 52, and part way through the left end section 54. A larger diameter bore 56 extends from the end of the bore 55 to the end of the section 54. The piston element 50 includes a piston section 57 slidably positioned in the bore 40 and having an annular flange 59 thereon within the bore 42, a small diameter piston element 60 slidably positioned within the bore 56 in the valve member element, a conical formation 61 extending from the section 57 toward the element 60, and a thin section 62 connecting the formation 61 and the piston element 60. An axial bore 64 extends from the left end of the piston element through section 57, the formation 61 and the section 62. A lateral bore 65 provided in the thin section 62 intersects the bore 64. The spring 37 acting upon the piston element 50 and the spring acting upon the head section 51 of the valve member element 49 normally maintain the piston element 60 against the right hand end of the bore 56.

The container of pressurized gas 11 is provided with a valve 66 which is connected to the gas port 24 of the accumulator and to the inlet gas port 46 of the regulator by tubing 67. The gas port 41 of the regulator is connected to the gas port 21 of the accumulator by tubing 69. Tubing 70 extends from the hydraulic fluid port 19 to a conventional hydraulic system (not shown) which includes a pressure compensated hydraulic pump, one or more hydraulically actuated devices, and appropriate valving for controlling the flow of fluid to the device or devices.

In operation, when the cylinder 16 of the accumulator has been filled with hydraulic fluid under pressure by the opera-

tion of the hydraulic pump, the valve 66 is fully opened and the system is in condition for use.

The pressure of the gas within the container 11 varies with ambient temperature and it is necessary that the gas initially delivered to the accumulator be at a specific value. Therefore, the container is pressurized so that the container is at that specific pressure when the ambient temperature is at the minimum expected value. Should the ambient temperature be above the minimum value when the valve 66 is opened, the pressure in excess of the specific value is bled off through the relief valve 27.

The pressurized gas acting on the area A_1 of the piston, which is equal to the cross-sectional area of the cylinder 17, urges the piston toward the fluid outlet 19 with a force sufficient to produce the desired pressure in the fluid within the cylinder 16. The force acting on the piston is balanced by the pressure produced by the pump in the hydraulic system, therefore, the piston does not move as long as the pump can supply the flow demand of the system. When the hydraulic system demands more fluid flow than the pump can supply, the piston moves toward the outlet 19 transferring fluid from the cylinder 16 into the hydraulic system. As the piston 15 moves, the gas driving the piston expands and decreases in pressure. The pressure regulator 12 compensates for this decrease in pressure by introducing pressurized gas into the cylinder 16 behind the piston section 28 to act on the area A_2 . The area A_2 is equal to the cross-sectional area of the cylinder 16 minus the area A_1 . The total force urging the piston 15 toward the outlet 19 is equal to the source pressure P_1 multiplied by the area A_1 plus the pressure P_2 acting on the area A_2 multiplied by the area A_2 . The pressure regulator 12 functions to maintain this total force constant throughout the stroke of the piston.

In the pressure regulator, the spring 37 which tends to move the piston element 50 and the valve member element 49 upwardly (to permit flow from the inlet 46 to the port 41) is opposed by the source pressure P_1 acting upon the element 49 and the pressure P_2 acting on the piston member 50. The source pressure P_1 acts upon an area A_3 equal to the area defined by the valve seat 47 and the pressure P_2 acts on an area A_4 equal to the cross-sectional area of the bore 40 minus the area A_3 .

When the sum of the forces produced by the source pressure P_1 acting on the area A_3 and by the pressure P_2 acting on the area A_4 falls below the force of the spring 37 (e.g. by virtue of a decrease in P_1), the valving assembly 36 moves upwardly separating the valve head 51 from the seat 47. Gas then flows past the seat 47 increasing the value of the pressure P_2 to balance the spring force.

The ratio of the area A_3 to the area A_4 in the regulator is equal to the ratio of the area A_1 to the area A_2 in the accumulator. Therefore, the pressures P_1 and P_2 acting within the regulator produce a constant force (balanced by the spring 37) which is proportional to the constant force produced by the pressures P_1 and P_2 acting upon the piston 15. The spring 37 is selected such that the ratio of the spring force to the required piston force is equal to the ratio of A_3 to A_1 (and A_4 to A_2).

As the piston 15 moves toward the outlet 19, the value of the source pressure P_1 constantly decreases due to expansion and the regulator 12 increases the value of the pressure P_2 to maintain the hydraulic fluid at a constant pressure.

When the period of high flow demand by the hydraulic system has ended, the pump in the system forces fluid back into the accumulator moving the piston 15 to the right. During the period that the accumulator is refilled with hydraulic fluid, the gas acting on the area A_1 is recompressed and forced back into the container while the gas acting on the area A_2 is vented to the atmosphere through the regulator 12. As the piston 15 moves toward the right, the gas acting on the area A_2 is forced into the regulator and acts on the area A_4 . The pressure acting on the area A_4 is now greater than the pressure required in conjunction with the pressure P_1 to hold the head 51 against

the valve seat 47. The force of the gas acting on area A_4 , aided by the source pressure acting upon the piston element 60, moves the piston section 57 against the spring 37 and separates the conical formation 61 from the edge of the end section 54 of the valve member element 49 to allow gas flow from the port 41 through the bores 65 and 64 to the vent port 44.

A great portion of the gas used during the first high flow demand period is reclaimed during the accumulator refilling operation. After refilling, the source pressure P_1 is somewhat less than the initial value due to the loss of the gas acting on the area A_2 . During the next high flow demand period, the regulator compensates for this pressure decrease by providing a somewhat higher P_2 value throughout the period. In this manner, the accumulator arrangement provides constant pressure hydraulic fluid flow throughout many periods of high flow demand using a relatively small volume of pressurized gas.

It will be seen that present invention provides a highly efficient accumulator arrangement of minimum size and weight wherein a source of pressurized gas is used to expell hydraulic fluid at constant pressure during periods of high flow demand and a great portion of the gas is recompressed during periods of low fluid flow demand.

I claim:

1. In a hydraulic system including an accumulator for storing hydraulic fluid under pressure and a piston movable within the accumulator to effect constant pressure on the fluid, the combination comprising:

first and second pressure surfaces on the piston;
a source of pressurized gas for acting on each of said pressure surfaces;
means for sensing the pressure of said gas on each of said pressure surfaces; and

regulator means for adjusting the pressure of said gas on one of said pressure surfaces in response to a change in pressure of said gas on the other of said pressure surfaces to maintain the total pressure acting on the piston from said source substantially constant.

2. Apparatus as in claim 1 wherein said regulator means comprises means for increasing the pressure of said gas on said second pressure surface as the pressure of said gas on said first pressure surface decreases during movement of said piston.

3. Apparatus according to claim 2 wherein said source is connected to said accumulator to provide free flow between said source and said first piston area whereby gas is returned to said source when the accumulator is refilled with hydraulic fluid.

4. Apparatus according to claim 3 wherein means are provided to vent said second piston area pressure when this pressure exceeds the value supplied by said regulator means whereby the gas acting on said second piston area is vented as said accumulator is being refilled with hydraulic fluid.

5. Apparatus according to claim 4 wherein said regulator means includes movable valve means for controlling gas flow from said source to said second piston area, said movable valve means having a third piston area acted upon by said source pressure and a forth piston area acted upon by said second piston area pressure, said valve means being urged in one direction by the pressure forces acting against said third and forth piston areas, and resilient means biasing said valve means against said pressure forces to allow said gas flow only when the sum of said pressure forces is below a predetermined value.

6. Apparatus according to claim 5 wherein the ratio of said third piston area to said forth piston area is equal to the ratio of said first piston area to said second piston area.

7. Apparatus according to claim 6 wherein said resilient means provides a force having the same ratio to the sum of the forces acting on said first and second piston areas as the ratio which the third piston area has to the first piston area.

8. Apparatus according to claim 5 wherein said movable valve means includes a valve member acted upon by said source pressure, a piston member acted upon by said second

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piston area pressure and movable relative to said valve member, and venting valve means carried by said members for venting the gas acting on said second piston area when there is relative movement between said members.

9. Apparatus according to claim 8 wherein said venting valve means includes a piston element carried by said piston

member and acted upon by said source pressure to cooperate with said second piston area pressure acting on said piston member to produce relative movement between said members when said second piston area pressure increases above the value delivered by said regulator means.

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