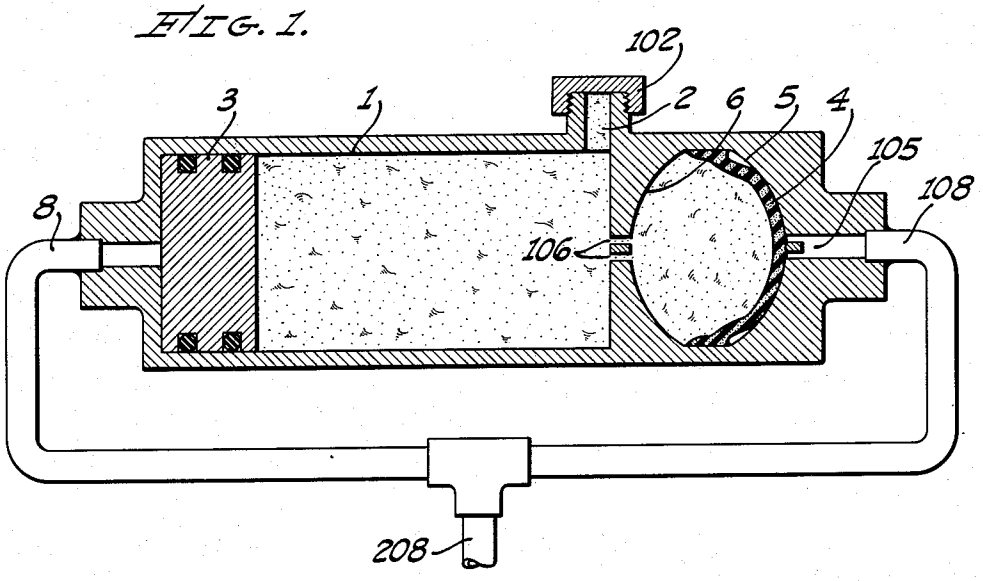
Dec. 22, 1953 R. E. SNYDER 2,663,320

ACCUMULATOR

Filed Nov. 18, 1946 2 Sheets-Sheet 1

FIG. 1.



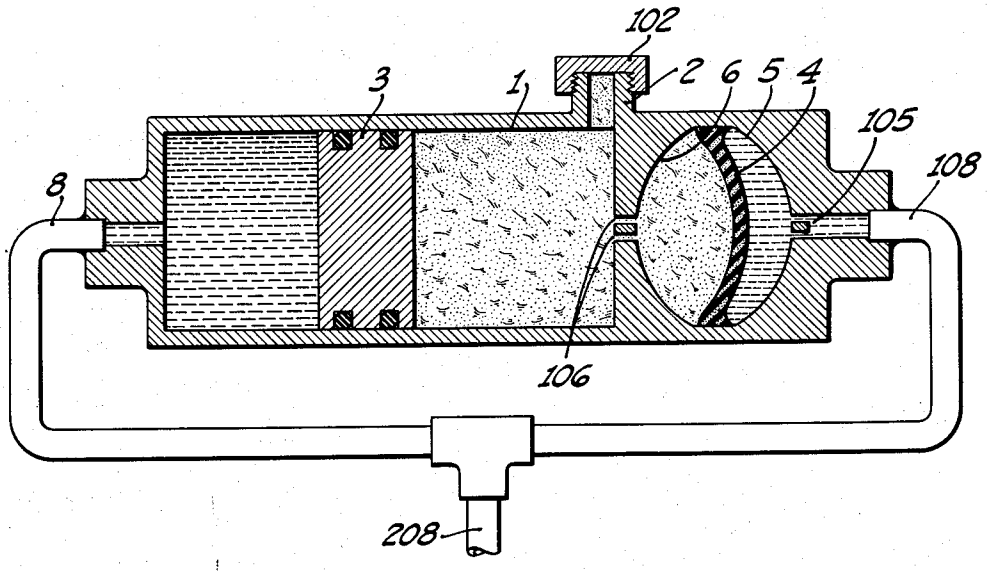


FIG. 2.

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ACCUMULATOR

Filed Nov. 18, 1946 2 Sheets-Sheet 2

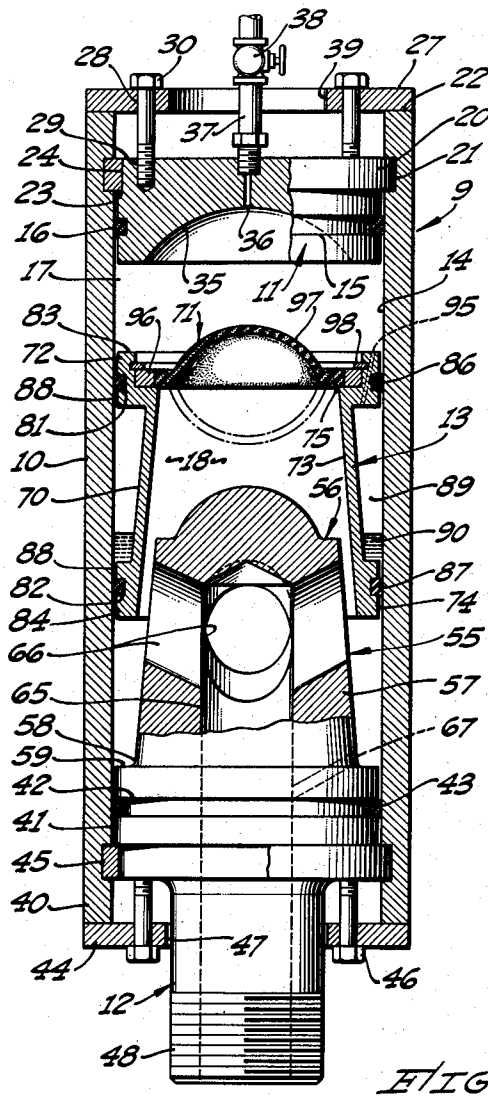


FIG. 3.

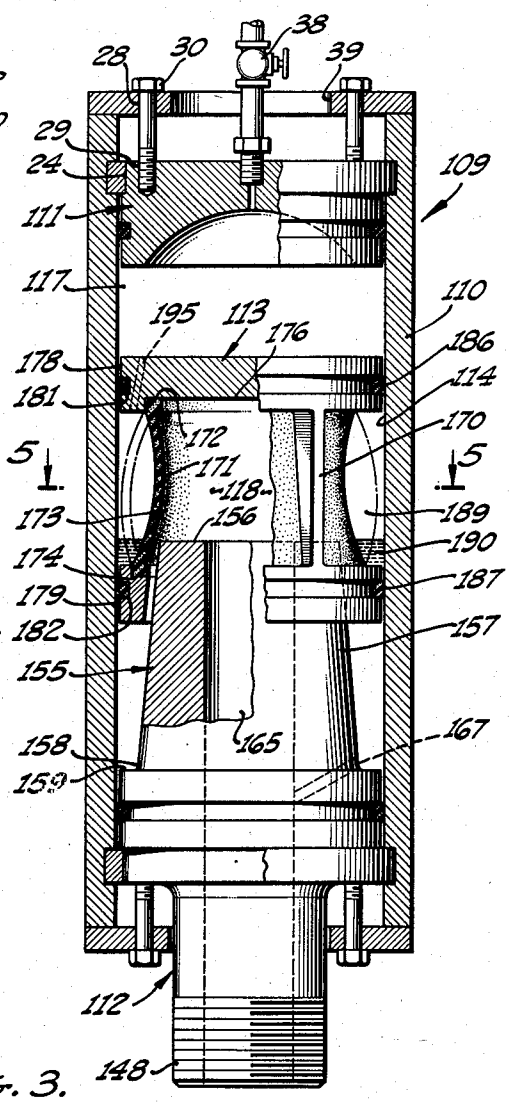


FIG. 4.

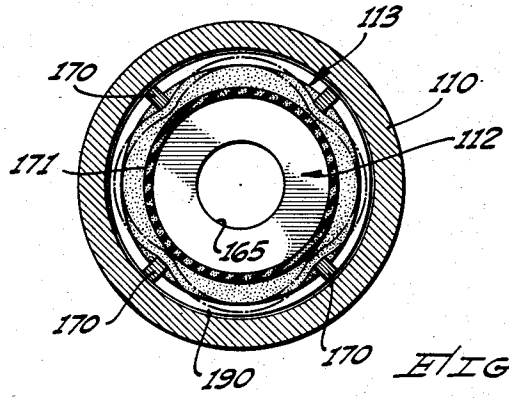


FIG. 5.

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Patented Dec. 22, 1953

2,663,320

UNITED STATES PATENT OFFICE

2,663,320

ACCUMULATOR

Robert E. Snyder, Pasadena, Calif., assignor, by mesne assignments, to Snyder Oil Tool Corporation, a corporation of California

Application November 18, 1946, Serial No. 710,490

14 Claims. (Cl. 138—31)

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My invention relates to the art of hydraulic pressure storage tanks, more commonly known as pneumatic hydraulic accumulators. In accumulators of this type, hydraulic fluid is stored under the pressure produced by a compressed gas within a common container. More particularly my invention relates to an improved means for separating the two fluid media, compensation for large pressure changes, and the transferring of minute pressure variation in the liquid to the gas and vice versa.

In order to avoid intermixture and/or absorption of the gas into the liquid, hydraulic accumulators commonly employ separating means between the two fluids, such as, for example, a diaphragm, a bellows, a bag or a piston. Thus fluid pressure on one side of the separating means is readily transferred to the fluid on the opposite side. Each of the above-described separating means has its preferred use and each has certain inherent limitations.

The diaphragm or bag types are extremely sensitive to minute pressure changes due to the relatively low weight and the low inertia factor of the relatively thin membranes from which they can be made. Membrane separators have the common failing, however, of being relatively large in area and therefore subject to certain destructive mechanical stresses at or near their extreme positions. Moreover they are weakened by continued creasing or folding and they may be torn or pierced quite easily, their large area increasing the chance of such damage or puncture.

The piston type, on the other hand, easily moves the full length of the hydraulic accumulator to adjust for any desired pressure. It is rugged and not easily damaged. However, its relatively greater weight introduces an inertia factor which makes it less sensitive to minute pressure variation. The necessary frictional engagement between hydraulic pistons and cylinder walls makes the piston slow to respond to rapid pressure changes. Many other inherent differences between the above types of accumulators will occur to those familiar with the art.

The present invention contemplates a major improvement of the piston type accumulator in which the primary object is to combine the sensitivity of the diaphragm, bellows, or bag type with the indefinitely large range of pressure variation of the piston type accumulator. In the present invention, a piston is provided which is free to move the full length of an accumulator cylinder to adjust for any major pressure change

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between the gas and the liquid, and a diaphragm or flexible element is provided and is free to flutter in response to minute pressure or volume variations which, in conventional accumulators, would not move the piston itself.

One object of my invention is to provide an accumulator having both a piston and diaphragm as described and wherein the diaphragm is mounted in the piston itself and moves therewith, thus making for economical manufacture and ease of assembly and maintenance.

An additional object of my invention as an alternate form, is to provide a tubular type diaphragm in the side of a piston whereby to achieve full sensitivity to small pressure variations while permitting direct, unobstructed flow through the liquid inlet port of the accumulator cylinder.

Still another object is to provide protective means for the diaphragm when there is no liquid in the accumulator, whereby to support the same so that the precharge pressure normally provided in the gas chamber will not extrude or damage the sensitive diaphragm. In both bag and diaphragm accumulators of conventional design, it is common practice to cover the liquid outlet port through the shell with a screen or orificed plate to prevent extrusion of the bag or diaphragm when the liquid pressure falls below the precharge pressure. Such a plate or screen in the shell often is undesirable however, since it forms an obstruction to the free flow of liquid into or out of the accumulator. The present invention provides a smooth metal wall to support the diaphragm during the minimum pressure condition, the diaphragm being held in some cases in a position out of line with the liquid orifice and hence not obstructing the same. This support means for the diaphragm may be adapted for either the flat or the tubular diaphragms above described as well as for any alternate construction.

A further object is to provide a cheap and efficient structure which is easy to assemble and service, and which may be constructed with any safety factor necessary for its projected use.

These and other objects of the present invention will become apparent from the following description of several preferred forms thereof, and from the drawings illustrating these forms in which:

Fig. 1 is a diagrammatic elevational section of an accumulator embodying my invention, illustrative of the basic principles thereof, and shown in a precharged position;

Fig. 2 is a section similar to Fig. 1, showing the device in an operative position;

Fig. 3 is a longitudinal vertical section of a preferred form of the accumulator having a substantially plate type diaphragm and with certain parts cut away to show the internal structure;

Fig. 4 is a similar view of another modified structure in which a tubular diaphragm is used in the piston and the liquid port is modified to accommodate it; and

Fig. 5 is a horizontal section taken along the line 5—5 in Fig. 4.

Referring now to the drawings and particularly Figs. 1 and 2 thereof, the fundamental principles of operation of my invention may be clearly understood. The numeral 1 indicates a hydraulic cylinder having a smooth interior bore in which a piston 3 is slidably supported and is free to move from one end of the cylinder 1 to the other, being limited in its motion by the end walls of the cylinder. A flexible cup-shaped diaphragm 4 is secured at one end of the cylinder 1 and enclosed in a chamber defined by spheroidally-shaped walls 5 and 6. The spaces to the left of the diaphragm 4 and to the right of the piston 3 are interconnected by means of a plurality of openings 106. These two spaces constitute a gas chamber which is adapted to be charged through a threaded nipple 2 projecting from the side of the cylinder 1. When the desired precharge pressure has been produced in the gas chamber, the nipple 2 is hermetically closed as indicated schematically by the screw cap 102.

The accumulator illustrated in Figs. 1 and 2 is adapted to receive liquid in spaces to the left of the piston 3 and to the right of the diaphragm 4 such liquid being delivered by a pair of end-connected ducts 8 and 108, respectively, which are joined to a common duct 208 for connection to a hydraulic system. Since the fluid chambers just described are interconnected they may, in effect, be considered as one chamber. Thus the accumulator shown in Figs. 1 and 2 is to be considered as having hermetically separated chambers, one adapted to receive fluid and one containing gas under pressure.

Fluid pressure in the above hydraulic system will force liquid into the liquid chamber above described causing the piston 3 to move to the right and the diaphragm 4 to move to the left thus compressing the gas in the gas chamber. The only pressure differential existing on the two sides of the diaphragm 4 is that occasioned by the differential pressure on the two sides of the piston 3 occasioned by the frictional drag thereof on the walls of cylinder 1.

The walls 5 and 6 of the diaphragm chamber are so formed as to provide a smooth support for the diaphragm in either of its limited positions. As shown in Fig. 1, the diaphragm is forced against the wall 5 by the precharge pressure in the gas chamber there being no fluid pressure exerted on the right side of the diaphragm. By virtue of the fact that a plurality of relatively small openings are provided at 105 and at 106, there is no tendency for the diaphragm 4 to be extruded into these openings when the diaphragm is supported either by the wall 5 or the wall 6.

As can be seen from an examination of Fig. 2, motion of the piston 3 within the cylinder 1 compensates for large changes in pressure of the fluid system connected at the ducts 208 while small fluctuations in pressure are compensated for by relatively small changes in the volume of the gas chamber permitted by fluttering or fluctuating motion of the diaphragm 4.

By reference now to Fig. 3 it will be seen that one preferred embodiment of the present invention employs a body 9 comprised of a tubular shell 10 having each end closed with plugs 11 and 12 affixed therein as end closures and provided with a piston 13 slidable in said shell between said end plugs. The piston 13 divides the body 9 into two separate and dependently variable chambers 17 and 18; the chamber 17 being above the piston 13 and the chamber 18 being below the piston 13 within body 9 so that any movement of piston 13 varies chambers 17 and 18 in a supplemental manner, one gaining such volume as the other loses. The shell 10 may be constructed from seamless steel tubing of sufficient length to provide the required capacity of the accumulator and having its bore 14 finished smooth as, for example, by lapping or honing, to provide a suitable internal surface for the piston 13 to ride upon and seal against. It should be noted further that the wall thickness of the shell 10 while sufficient to withstand the working pressure of the accumulator, should not be thin enough to bulge outwardly under such working pressure and thereby permit gas or liquid to seep past the piston in either direction. The plug 11 located at the "gas" end of the accumulator may be affixed within shell 10 in any suitable manner provided a leakproof seal is established. In the form shown in Fig. 3 the plug 11 is provided with an annular groove 15 in which a packer seal 16 is positioned between the plug 11 and the bore 14 of the shell 10. This sealing packer 16 may be of any desired type such as an O ring, a chevron packer, or any other suitable means unaffected by the fluid and capable of withstanding the temperatures and/or pressure required in the use of the accumulator.

The plug 11 is locked into the shell 10 by the use of a split shear ring 20 seated in an annular groove 21 in the bore 14 inwardly from the end 22 of the shell 10. The shear ring 20 is divided into three or more sectors so that it may pass through bore 14 and be placed in the groove 21 of the shell. A complementally shaped shoulder 23 located on the plug 11 outwardly from packer 16 provides an abutment for plug 11 against shear ring 20 and the inner wall 24 above shoulder 23 holds the shear ring 20 in the groove 21. An orificed bolt plate 27 is provided to abut the outer end 22 of the shell 10 and has a plurality of holes 28 drilled therethrough. Correspondingly placed holes 29 are bored and threaded in the plug 11 so that bolts 30 placed in the holes 28 and threadedly engaged in the plug 11 may be drawn up tight to hold the plug 11 shouldered against the shear ring 20 in the groove 21 and lock both the plug 11 and the bolt plate 27 securely to the end of shell 10. The removal of bolts 30 will permit the plug 11 to be slipped down inside the shell 10, permitting removal of the shear ring 20 from the groove 21, and complete disassembly of the plug 11 and the shell 10. It will be evident that other methods of attaching the plug 11 to the shell 10 may be used such as threading, welding, keying, etc., and that the means shown is illustrative only.

The plug 11 is provided with a domed internal face 35 having a hole 36 extending therefrom to the outside of the plug 11. Threadedly secured in the hole 36 is a gas inlet pipe 37 with a suitable valve 38 and gas control means (not shown) attached thereto. The pipe 37 extends from the

plug 11 through an opening 39 in the bolt plate 27 to the outside of the accumulator.

The opposite end 49 of the shell 10 is provided with a plug 12 which, while it may be attached to shell 10 in any suitable manner, is preferably attached thereto in a similar manner to the plug 11. The plug 12 is comprised essentially of a central body portion 41 in the cylindrical surface of which is formed an annular packing groove 42. A packing ring 43, substantially the same as the packer 16 used in the plug 11 is seated in the groove 42 to seal the interstice between the plug 12 and the bore 14 of the shell 10. A second bolt plate 44, a split ring 45, and bolts 46 are used to lock the plug 12 into the shell 10. A neck 48 extends outwardly from the body portion 41 through an opening 47 in the bolt plate 44. This neck 48 is threaded as shown or may be flanged or otherwise provided with means for attachment to a source of liquid.

The opposite end 55 of the plug 12 extends for a substantial distance inwardly of the central body portion 41 and is provided with a supporting face 56 for a piston diaphragm 97 to be described presently. This inwardly extending portion 55 is formed with tapered sides 57 which are substantially complemental to the bore 73 of the piston 13.

Inwardly from groove 42 and at the base 58 of the inwardly extending portion 55 of the plug 12 is a shoulder 59 which serves as a base and stop for the extreme (minimum pressure) position of the piston 13. The plug 12 is further provided with a main bore 65 extending from outer end 48 axially through plug 12 to a midposition within the inwardly extending portion 55. A plurality of cross bores 66 extend from the tapered sides 57 of the inwardly extending portion 55 to communicate with the bore 65 whereby fluid may enter from the neck 48 and pass through the bores 65 and 66 into the interior of the accumulator. A small bleed hole 67 extending from shoulder 59 down into bore 65 avoids entrapment of fluid between the piston 13 and the shoulder 59.

Thus the body 9 of the accumulator has openings in the end plugs 11 and 12 for the entrance of gas into the chamber 17 and of liquid into the chamber 18 on their respective sides of the piston 13.

As a general rule at least one of the plugs 11 or 12 should be removably attached to shell 10 so that its removal will permit removal of piston 13 from shell 10. In Fig. 3, both plugs 11 and 12 are attached to and sealed against shell 10 by identical means and either or both may be removed. Selection of a construction permitting the removal of the plug 11, the plug 12, or both plugs depends upon the desire of the manufacturer, the particular use to which the accumulator is to be put, and the attendant structure with which it must be operated.

The piston 13 is comprised essentially of a cylindrical body 70 and has a flexible diaphragm 71 mounted in the upper end 72 thereof. As stated, the bore 73 of the piston is tapered substantially complementally to the taper 57 on the plug 12. The lower end of the piston 13 forms a skirt with a flat face 74 which is adapted to abut and rest on the shoulder 59 of the plug 12 when in the extreme downward position. With the piston 13 in this rest position, sufficient clearance is provided between its bore 73 and tapered face 57 of plug 12 to avoid sticking or seizure, and the upper end 75 of the bore 73 is substantially in alignment with the face 56 of plug 12. The diaphragm 71 rests against face 56 of plug 12 when the piston is in this position.

The outside diameter of the piston 13 is slightly less than the diameter bore 14 of shell 10 so that it slides freely therein. The skirt is further provided with grooves 81 and 82, one near the top 83 and one near the bottom 84 of the piston 13 into which grooves packing means 86 and 87, respectively, similar to packer 16, are positioned to seal the interstice 88 between the piston and bore 14. Between the packing grooves 81 and 82 the outer wall of the skirt of the piston 13 is relieved to provide a chamber 89 useful as a pocket for oil to lubricate the piston. Oil 90 or other suitable lubricant may, if desired, be placed in this space. Bleed holes 95 from the chamber 17 above the piston 13 leading behind the packing 86 and opening into the chamber 89 serve to balance the pressure of the gas in the chamber 17 above the piston 13 with that in the chamber 89. The hermetic seal between the gas in the chamber 17 above the piston 13 and the fluid in the chamber 18 below the piston is effected by the lower packer 87 while the upper packer 86 merely serves to position and align the piston 13 within the bore 14 of shell 10.

If, for example, the fluid in the lower part of the accumulator were a lubricant liquid, bleed holes 95 might be omitted and a second set of bleed holes (not shown) between chamber 18 below the piston 13 and chamber 89 could be substituted. In this latter case the seal would be effected by the upper packing 86 leaving the lower packer 87 to serve to align and position the piston 13. One or the other set of bleed holes should always be used to avoid the entrapment of gas or liquid under pressure in chamber 89, which in turn could result in sticking of the piston at low gas and/or liquid pressures.

As previously stated, the diaphragm 71 mounted in the piston 13 rests upon and is supported by the convex face 56 of the plug 12 when the piston is in the lowermost position. The fit between the plug 12 and the piston 13 adjacent the diaphragm is close enough to avoid any damage to or extrusion of the diaphragm under the precharge gas pressure in the chamber 17. At any other position when the liquid in the chamber 18 on the lower side of the diaphragm counterbalances the gas pressure in the chamber 17 above the piston, the diaphragm serves as a virtually weightless, non-resistant membrane floating between, and separating the respective fluids, and is furthermore, extremely sensitive to slight volume variations in either the gas or the liquid side with negligible inertia or frictional resistance to movement. Thus large changes in the volume ratio between the gas chamber 17 and the liquid chamber 18 are compensated for by motion up or down of the piston 13, and small volume changes are compensated for by movement of the diaphragm 71 within the piston 13.

The diaphragm 71 is formed with a base ring 96, to which is fastened the dome shaped diaphragm sheet 97, the entire unit being secured in the piston 13 by a snap ring 98. There are obviously a number of alternate methods of attaching the diaphragm to the piston, any of which, including direct bonding of the diaphragm sheet 97 to the body of the piston 13 itself, may be used within the scope of the present invention. Leakage around the edge of the diaphragm 71 from the chamber 17 to the chamber 18 around the piston 12, or vice versa, can be prevented by

the use of suitable cement, packers or other means (not shown) as required.

In the present form of my invention the base ring 96 is made of metal and the diaphragm sheet 97 is a synthetic rubber such as Hycar, neoprene, or similar material, which is bonded directly to the metal itself with one or another of the commercial processes for such bonding known in the art.

The diaphragm sheet 97 is of sufficient strength so as (when in an extended position shown) to easily move the piston 13 against the friction of the piston packers 86 and 87 against the walls of the bore 14. Furthermore the diaphragm is sufficiently flexible to move freely in response to very minute pressure changes, has a low inertia factor and is tough and relatively unstressed within the normal range of movement. By reason of the previously mentioned close fit between the plug 12 and the piston 13, the diaphragm is not forced into the space between these two parts even by high gas precharge pressures and is substantially unaffected by any liquids with which it must come in contact. In some cases an elastic material may be used or in others an inelastic material. However, a wide departure from these presently preferred specifications can be made without departing from the scope of the present invention.

By reference to the alternate position of the diaphragm shown in dotted lines, one example of the possible range of movement may be seen. A molded cup-type diaphragm substantially as shown and used in a standard six inch accumulator, provides a volume change of 8.5 cubic inches when moved from one extreme position to the other without any motion whatsoever on the part of the piston itself.

The molded cup is moved from one extreme position to the other with minimum elastic stretch because of its normal preformed shape. In any event the exact shape, size, thickness, material, and contour of the diaphragm may be varied from flat to globular to meet whatever requirements seem necessary in the particular accumulator. The resultant shape of the supporting faces as for example face 56 on plug 12 will be determined by that found best for the particular shape of diaphragm used. The convex supporting surface shown in Fig. 3 on plug 12 is but one possible form which has been found useful with the cup-shaped diaphragm 71. In general, a diaphragm of the type shown in Fig. 3 mounted in the piston substantially as shown will be referred to as a flat diaphragm while the form shown in Fig. 4 will be referred to as a tubular diaphragm. In fact all possible forms of flexible or readily deformable membranes or walls including closed bags, open bags, bellows and Sylphon types, semi-bag types such as the cup diaphragm shown in Fig. 3 as well as completely flat types constructed of synthetic rubber, metal, or any other suitable material will all be included in the broad term, diaphragm, as used in the specification and claims hereof.

Figs. 4 and 5 illustrate a further modification of the structure of Fig. 3 wherein a diaphragm 171 in a modified piston 113 is substantially tubular in shape and is located in the sides of the piston 113 instead of in the top as in the form shown in Fig. 3. In this modification the body 109 of the accumulator is comprised of a tubular shell 110 having end plugs 111 and 112 affixable therein in any suitable manner but shown the same as in Fig. 3. The piston 113 is positioned in bore 114 of shell 110 in the same manner as the previously described embodiment and divides body 109 into two chambers 117 and 118, respectively, above and below the piston 113. As before, both plugs and piston are provided with sealing means against leakage in the manner previously described. There are, however, several changes in the lower plug 112 and in the piston 113 to meet the requirements of the tubular type diaphragm 171 in contradistinction to those required for the flat type diaphragm.

Primarily the plug 112 has a bore 165 completely therethrough from its outer end 148 to its inner face 156. There are no cross bores for fluid, only the small bleed hole 167 still being provided to prevent entrapment of fluid. The plug 112 is provided with a shoulder 159 at the base 158 of the inwardly extending portion 155 upon which the piston 112 may rest when in the extreme downward position. The sides of the inwardly extending portion 155 are smoothly tapered as indicated by the numeral 157 to conform to the bore 173 of the unstressed diaphragm 171, and the upper face 156 of plug 112 is substantially flat to conform to the inside face 176 of the piston 113. Thus fluid entering the accumulator through the bore 165 passes directly up inside of or toward the bore 173 of the piston 113.

The piston 113 is comprised essentially of an upper portion 178 and a lower portion 179 which two portions are rigidly joined by a plurality of webs 170 which form a webbed skirt. Packing grooves 181 and 182 are formed in the outer surface of both upper and lower portions, respectively, of the piston 112 in which packers 186 and 187 are suitably disposed to ride against the walls of the bore 114 to seal the piston 113 within the shell 110 in substantially the same manner as that described for the piston 13 in Fig. 3. In the webbed skirt of the piston 113 between the upper and lower portions 178 and 179, and inside the webs 170, the tubular diaphragm 171 is affixed by any suitable method to said upper and lower portions, for example by bonding to the metal so that the diaphragm is firmly held and no leakage is permitted. An annular chamber 189 is provided surrounding the diaphragm and communicates with the gas chamber 117 above the piston 113 by one of more bleed holes 195 through which the gas may circulate to equalize the pressure between the two chambers 117 and 189. Fluid or other lubricant 190 may optionally be placed in the chamber 189 to lubricate the packers 186 and 187 used in the piston.

The inside face 173 of the diaphragm 171 is relatively smooth and adapted to seat against the tapered portion 157 of the plug 112. In the extreme downward position of the piston 113 when its lower face 184 is resting against the shoulder 159 the upper face 156 of the plug 112 rests substantially against the inside upper face 176 of the piston 113, the diaphragm 171 being supported by the tapered portion 157 of the plug and hence protected from extrusion or damage by the precharge gas pressure in the chambers 117 and 189. In any other position the liquid pressure in the chamber 118 on the inside of piston 112 counterbalances the gas pressure on the outside of diaphragm 171 in the chambers 189 and 117.

The tubular diaphragm 171 is free to bulge radially from an inward position as shown in solid lines to an outward position as shown in dotted lines in Figs. 4 and 5. The volume variation due to this motion of the tubular diaphragm

is greater than the equivalent motion of the flat diaphragm type shown in Fig. 3 because the side wall area of a piston is usually larger than the end area. However, its action in response to small pressure variations is substantially the same as in the flat diaphragm type. In an extreme case if the piston should stick, the hydraulic pressure could press the tubular diaphragm 171 out against the walls of bore 114. The lubricant 190 in the chamber 189 would lubricate any contact of diaphragm 171 against the walls of shell 110 and no damage would result.

The terms "pneumatic-hydraulic accumulator," "accumulator," or "hydraulic accumulator" are used interchangeably herein to designate a unit designed to store hydraulic fluid under pressure as a reserve power source, or to absorb and suppress fluid volume variations or hydraulic surge in a system which in turn would cause a pressure variation in that system.

In the oil industry and elsewhere a unit designed to relieve hydraulic surge is commonly called an "alleviator." Such a unit works as a relief valve to allow the escape of fluid surges which tend to raise the pressure in a system. However, they must be reset for every different line working pressure, and do not absorb such surges and feed them back into the line during the "below-average pressure-levels" of the surge cycle, but merely bleed off excess fluid to eliminate any excess which would cause pressures above that required. The inertia factors of conventional alleviators are usually much too high to respond to vibrational pressure surges although they are quite useful on very slow pressure surge cycles.

The subject accumulators are valuable as hydraulic power reservoirs and are particularly valuable to absorb and dissipate hydraulic surge. In this latter sense they can be called "alleviators," but with the understanding that they store up surge fluid and feed it back into the system rather than bleeding it off to a reservoir. More broadly, the present invention can be used in any installation wherein a commercial bag, diaphragm, bellows, piston or other type accumulator or "water hammer arrester" is now being used with beneficial results flowing from its improved structure.

The operation of the present invention for example in an oil-hydraulic pneumatic system may be briefly described as follows: The accumulator is assembled into the hydraulic system in a substantially vertical position. It will operate in any position but piston types as well as all others drain best and are most efficient if the oil port is down. In all bag and diaphragm types the heaviest fluid should be on the bottom and hence the air port should be at the top. All air is bled from the hydraulic system and the hydraulic pressure then reduced to zero. Gas, such as, for example, nitrogen (desiccated) is put, under pressure, into the accumulator through the valve 38 and pipe 37. This gas pressure forces the piston 13 down to its lowermost position which forces practically all fluid out of the unit. The precharge gas pressure is then built up to some predetermined value usually between one-third and one-half of the probable working pressure of the system. The valve 38 is then closed and the hydraulic pressure is turned on. As the pressure in the system builds up to its working value, oil enters the accumulator through the oil ports 66 and against the piston 13 which is moved upwardly against the gas pressure until the gas and oil pressures are equalized. The piston 13 stops moving when the line working pressure is reached and the subsequent smaller volume variations, engendered by pump output fluctuations or the system valves, are absorbed by reciprocal movement of the diaphragm.

If a further major pressure change takes place caused by a surge volume of fluid greater than can be handled by movement of the diaphragm alone, or by a change in the operating pressure of the system, then the piston is moved to a new position, and the system continues to operate at either a higher or lower average pressure level than before with the diaphragm still vibrating with small surges as before. This accumulator may be adapted for use in any hydraulic system to handle any required fluid below the piston and cushioned against a suitable gas above the piston.

While the particular apparatus herein shown and described in detail is fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that it is merely illustrative of the presently preferred embodiments of my invention, and that I do not mean to limit myself to the details of construction or design herein shown, other than as defined in the appended claims.

I claim:

1. A pneumatic hydraulic accumulator comprising: a tubular body with closed ends; a piston positioned within said body for limited sliding motion therein, and contacting the wall of said body whereby to hermetically divide said body into two chambers, one of said chambers being parted whereby to be precharged with gas and the other of said chambers having inlet means to receive varying quantities of liquid; a diaphragm in said piston exposed on one side to said gas chamber and on the other to said liquid chamber; and means in said body for supporting said diaphragm when said piston approaches a limit of said motion thereof.

2. A pneumatic hydraulic accumulator comprising: a tubular body with closed ends; a piston positioned within said body for limiting sliding motion therein, and contacting the wall of said body whereby to hermetically divide said body into two chambers, one of said chambers being parted whereby to be precharged with gas; a second port in said body adapted to supply liquid under pressure to the other of said chambers; a diaphragm transversely disposed and secured in said piston, exposed on one side to said gas chamber and on the other to said liquid chamber; said diaphragm being flexible to permit axial motion relative to said piston; and means for supporting said diaphragm when the pressure of said liquid is less than said precharged gas pressure.

3. A pneumatic hydraulic accumulator comprising: a tubular body with closed ends; a piston positioned within said body adapted for limited sliding motion therein, and hermetically dividing said body into two chambers, one of said chambers being adapted to be precharged with gas; a port in said body adapted to supply liquid under pressure to the other of said chambers; a diaphragm secured in said piston, exposed on one side to said gas chamber and on the other to said liquid chamber; and adapted for radial flexing motion; and means for supporting said diaphragm when the pressure of said liquid is less than said precharged gas pressure.

4. A pneumatic hydraulic accumulator comprising: a tubular body having closed ends; a piston slidably supported in said body and contacting the wall thereof to hermetically separate said body into two chambers, one being parted to be precharged with gas and the other connected to receive liquid; a flexible diaphragm in said piston exposed on one side to said gas chamber and on the other to said liquid chamber; means in one of said closed ends forming an inlet port for said liquid receiving chamber; and means associated with said inlet port to prevent impingement of said liquid on said diaphragm.

5. A pneumatic hydraulic accumulator comprising: a tubular body having closed ends; a piston slidably supported in said body and contacting the wall thereof to hermetically separate said body into two chambers, one being ported to be precharged with gas and the other connected to receive liquid, a flexible diaphragm in said piston exposed on one side to said gas chamber and on the other to said liquid chamber; and a plug forming one of said closed ends adjacent said liquid chamber, said plug having an inwardly extending portion positioned and shaped to support said diaphragm against damage by said precharge pressure, said extending portion having a liquid port formed therein disposed and adapted to direct incoming fluid away from said diaphragm.

6. A pneumatic hydraulic accumulator comprising: a tubular body having closed ends; a piston slidably supported in said body and contacting the wall thereof to hermetically separate said body into two chambers, one being ported to be precharged with gas and the other connected to receive liquid; a flexible diaphragm in the top of said piston exposed on one side to said gas chamber and on the other to said liquid chamber; and a plug forming one of said closed ends adjacent said liquid chamber, said plug having an inwardly extending portion with a face on the inner end thereof shaped and positioned to support said diaphragm when said precharge pressure exceeds said liquid pressure, said extending portion having a liquid port formed therein disposed to direct incoming liquid through the side of said extending portion whereby to avoid impingement thereof against said diaphragm.

7. A pneumatic hydraulic accumulator comprising: a tubular body with closed ends; a piston positioned within said body and contacting the wall thereof for limited sliding motion therein, whereby to hermetically divide said body into two variable volume chambers, one of said chambers being ported to be precharged with gas; a diaphragm secured in said piston, exposed on one side to said gas chamber and on the other to said liquid chamber; and normally unsupported to permit limited radial flexing motion thereof; and a plug forming one of said closed ends adjacent said fluid chamber, said plug having an inwardly extending portion with sides shaped to support said diaphragm when said precharge pressure exceeds said fluid pressure, said extending portion having a fluid port forward therein disposed to direct incoming fluid axially and away from impingement thereof against said diaphragm.

8. A pneumatic hydraulic accumulator comprising: a tubular body having closed ends; a piston slidably positioned within said body to divide said body into two chambers, one to receive gas and the other to receive liquid; sealing means in said piston positioned to make a slidable fluid seal against said tubular body; a flexible diaphragm in said piston exposed on one side to said gas chamber and on the other side to said liquid chamber; and a plug forming the closure of the liquid receiving portion of said body and comprising a central body portion, an inwardly extending portion having a surface thereon substantially complemental to said piston, said plug having a port formed therein adapted to connect said liquid chamber to a source of liquid, said port being disposed and positioned to be covered by a non-flexible portion of said piston when said precharged gas pressure exceeds said liquid pressure.

9. A pneumatic hydraulic accumulator comprising: a tubular shell having closed ends, one of said ends having a port therein to receive a gas, and the other of said ends having a port therein to receive varying quantities of liquid; a piston slidably positioned within said shell between said closed ends and sealably dividing the space within said shell into a gas chamber and a liquid chamber; and a diaphragm in said piston open on one side to said gas chamber and on the other side to said fluid chamber, said piston being movable in said shell and said diaphragm being movable with respect to said piston to compensate for relative volume variations between said gas and said liquid chambers.

10. A pneumatic hydraulic accumulator which includes; enclosure means forming a gas chamber and an adjacent liquid receiving chamber, said chambers having a plurality of common wall sections separating said chambers from each other and movable in response to differential pressures in said chambers; one of said wall sections being deformable to respond to minor pressure differentials between said chambers, and another of said sections being displaceable in response to major pressure differentials to equalize the pressure between said chambers whereby said first section is responsive to pressure differentials at all working pressures in said chambers; and means for connecting said liquid receiving chamber to a source of liquid subject to variable pressure.

11. A pneumatic hydraulic accumulator comprising: a tubular body with closed ends; a piston slidably positioned within said body and having fluid tight contact with the walls thereof whereby to hermetically divide said body into two chambers of dependently variable volume; and a diaphragm secured in said piston exposed on one side to said gas chamber and on the other to said liquid chamber; said diaphragm being movable with respect to said piston whereby to permit relative volume variations between said two chambers without movement of said piston and port means for introducing gas into one of said chambers and liquid into the other.

12. In a pneumatic hydraulic accumulator: a fluid tight enclosure; a plurality of spaced fluid connections in the wall of said enclosure to admit gas and liquid into said enclosure; and internal separatory means in said chamber adapted to separate said gas and liquid, said separatory means including at least two wall sections having fluid tight contact with the wall of said enclosure, one of said wall sections being slidable to vary the relative volume of said gas and liquid in said enclosure, and the other of said wall sections being movable independently of motion of said first section to vary said relative volumes, said wall sections having substantially different resistance to motion.

13. In a pneumatic hydraulic accumulator,

the combination of: a cylinder closed at its ends; a piston slidable in said cylinder in sealing engagement therewith whereby to form a plurality of chambers therein; means for admitting gas into one of said chambers; means for connecting the other of said chambers to a source of pressure liquid; and a diaphragm movable with respect to said piston and having one of its faces open to the gas in said gas chamber and its other face open to said pressure liquid, whereby said diaphragm and said piston are differentially responsive to variations in pressure of said gas and said liquid.

14. In a pneumatic hydraulic accumulator, the combination of: enclosure means forming a chamber; means for admitting gas to said chamber; means for admitting liquid under variable pressure to said chamber; and two differentially

movable wall sections in said chamber dividing the same into gas and liquid compartments, said wall sections being differentially responsive to variations in the pressures of said gas and liquid, one of said wall sections being readily responsive to small pressure changes and the other wall section being responsive only to relatively larger pressure changes.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,365,994	Ashton	Dec. 26, 1944
2,406,197	Christensen	Aug. 20, 1946
2,417,256	Kremiller	Mar. 11, 1947