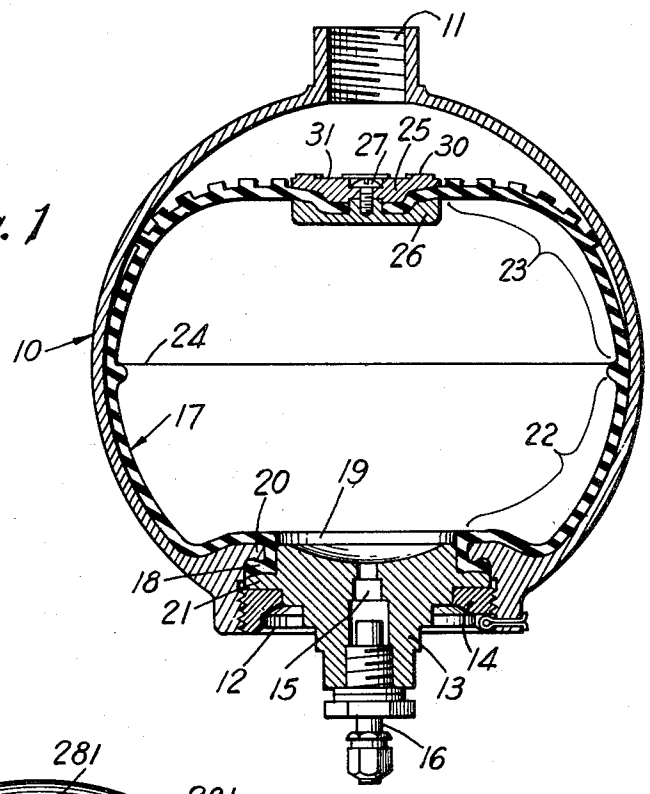
Feb. 27, 1951 R. S. MILLER 2,543,585

ACCUMULATOR

Filed Jan. 13, 1945 2 Sheets-Sheet 1

Fig. 1



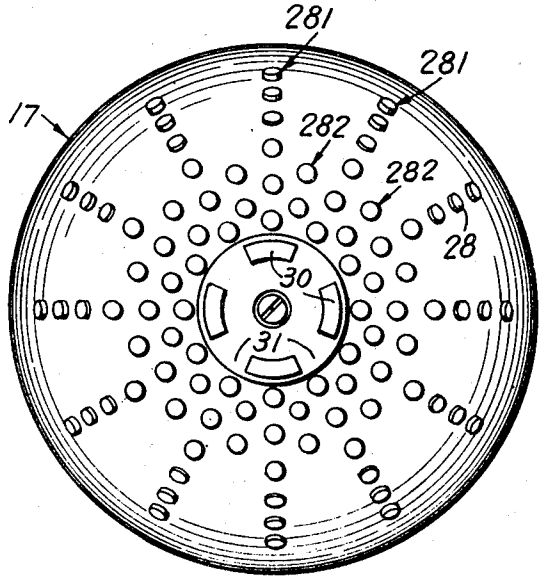


Fig. 2

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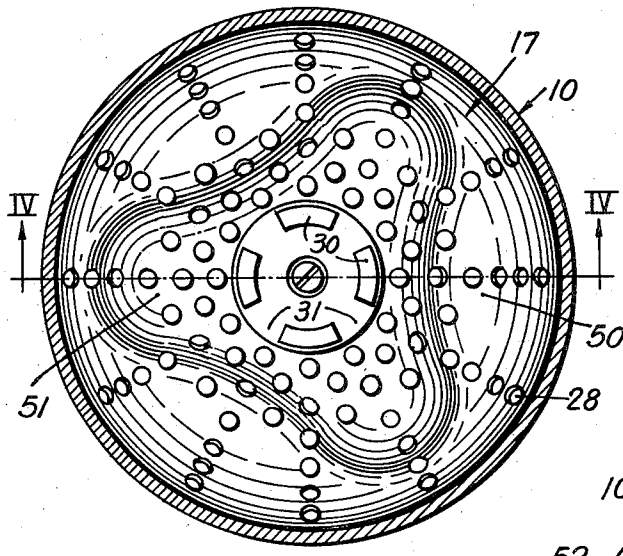

Fig. 3

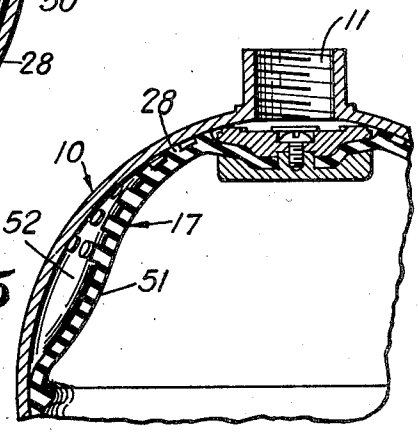

Fig. 5

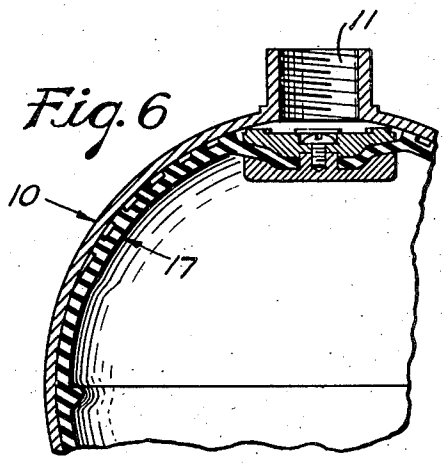

Fig. 6

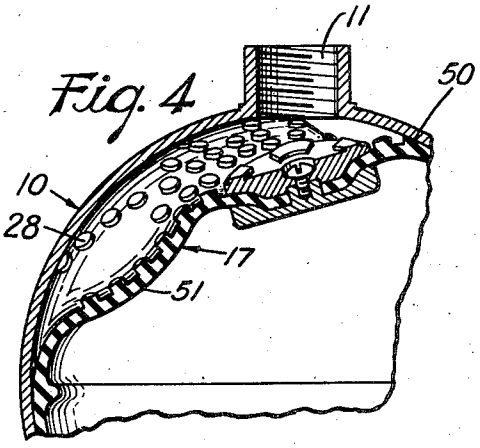

Fig. 4

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UNITED STATES PATENT OFFICE

2,543,585

ACCUMULATOR

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Application January 13, 1945, Serial No. 572,623

5 Claims. (Cl. 138—30)

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This invention relates to accumulators for use in hydraulic systems and relates particularly to a bladder construction for use in such accumulators to separate the working fluid, usually a liquid, from a gas, usually air, which is compressed to maintain a pressure on the working fluid.

An object of the invention is to provide a bladder construction that is simple and practicable and is effective to reduce or prevent the trapping of working fluid.

Other more specific objects and features of the invention will become apparent from the description to follow of a particular embodiment that is illustrated in the drawing.

Accumulators of the general type to which this invention relates are in common use in hydraulic systems for storing hydraulic fluid under pressure and supplying it to the system without excessive loss of pressure when the supply pump is not operating or when the demand exceeds the capacity of the pump.

A common type of such accumulator consists of a generally spherical steel shell having an air opening at one end and a liquid opening at the other end. To prevent mixing of the liquid with the air the shell contains a generally spherical flexible bladder having an opening secured to the shell at the air opening thereon so that the space within the bladder is filled with air and any space between the bladder and shell is filled with the working liquid. Normally, the bladder is about half collapsed so that the space between the bladder and shell filled with working liquid is equal to about half the total volume of the shell. The air is, of course, compressed to the pressure of the liquid, and if the pressure of the liquid in the system (which is connected to the liquid opening of the shell) diminishes, liquid is forced out of the shell by the pressure of the air within the bladder. The bladders are intended to be so designed that the closed end telescopes into the portion adjacent the air opening when liquid flows into the shell and is distended when liquid is withdrawn from the shell. If this telescoping action takes place uniformly in the manner intended, very nearly all of the liquid is forced out of the shell when the pressure in the system is reduced sufficiently to expand the bladder to the end of the shell where the liquid opening is located, resulting in substantially 100 per cent volumetric efficiency.

However, these bladders do not always expand and contract uniformly in the desired and intended manner. For various reasons, some of

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which are known and some are unknown, the bladders sometimes fold in unexpected manner when liquid is withdrawn from the shell, with the result that the end of the bladder adjacent the liquid opening may contact the shell around the opening and effect a seal therewith while another portion of the bladder more remote from the liquid opening is spaced from the shell. This results in the trapping of liquid by the bladder and prevents the escape of the liquid through the opening so that the volumetric efficiency of the accumulator is reduced.

The present invention resides in the provision of external buttons or bosses on the bladder which bosses contact the shell and maintain the surface of the bladder intermediate the bosses spaced away from the shell so that passages are provided for the flow of liquid toward the shell opening even though the portion of the bladder adjacent the opening be expanded against the shell before portions more remote from the opening contact the shell. This permits trapped liquid to escape and insures a relatively high volumetric efficiency.

It has also been a common practice for some time to provide a metal disc on the bladder juxtaposed to the liquid opening in the shell to cover the opening when the bladder is fully expanded and prevent the extrusion of the flexible bladder material into the opening. Such discs sometimes fit sufficiently close against the shell over their entire circumference to prevent or greatly hinder the escape of liquid if the bladder expands in such a way as to carry the disc against the opening before all the liquid has been exhausted. In accordance with the present invention, trapping of liquid from this cause is prevented by providing raised shoulders at intervals around the edge of the disc to prevent it from sealing against the shell, while at the same time, avoiding the provision of gaps or cracks of sufficient width to permit extrusion of the bladder material.

The disc construction is preferably used in combination with the bosses or buttons on the exterior surface of the bladder, the two combining to prevent the trapping of liquid in most cases.

A full understanding of the invention may be had from the following detailed description with reference to the drawing in which;

Fig. 1 is a longitudinal section through an accumulator incorporating a bladder in accordance with the invention;

Fig. 2 is a view looking at the closed end of the bladder;

Fig. 3 is a sectional view taken in the equatorial plane of the accumulator showing one shape that the bladder may assume when partially collapsed, the bladder being shown in plan.

Fig. 4 is a section taken in plane IV—IV of Fig. 3;

Fig. 5 is a section similar to Fig. 4 but showing the bladder expanded to a greater extent than in Fig. 4; and

Fig. 6 is a section similar to 4 and 5 showing the bladder almost completely expanded.

Referring first to Fig. 1 the accumulator therein disclosed comprises a substantially spherical shell 10 having a liquid opening 11 at one end and having a relatively large opening 12 at the other end. In Fig. 1 the accumulator is shown positioned with the liquid opening 11 at the top and the large opening 12 at the bottom, which position is preferred by some users because any air that might be mixed with the liquid entering with the opening 11 will rise to the top and will be ejected from the shell when liquid flows out. However, these accumulators are sometimes installed in other positions and when mounted on movable craft such as airplanes, they may be required to operate in any position.

The large opening 12 is normally closed by a plug 13 which is secured in place by a lock ring or nut 14 that is screwed into the threaded outer portion of opening 12. The plug 13 in turn defines an air passage 15 which is normally closed by a fitting 16 which permits the forcing of air into the accumulator under pressure.

There is positioned within the shell 10 a bladder 17 which bladder is locked to the shell by the plug 13 and communicates with the air passage 15. The bladder 17 has a flange 18 at its opening 19 which flange is clamped between an annular shoulder 20 on the shell and an annular flange 21 on the plug 13. This effects a seal between the bladder and the shell so that no air can escape from the inside of the bladder to the space between the bladder and the shell.

The bladder 17 is preferably provided with a stationary portion 22 which is formed to fit snugly against that portion of the shell extending from the opening 12 substantially to the equator, and a flexible portion 23 which extends from the equator to the closed end of the bladder and is adapted to fold into the stationary portion 22 to a lesser or greater extent when liquid enters the shell opening 11 and compresses the air within the bladder. If air becomes completely exhausted from within the bladder, for any reason, and pressure liquid enters the opening 11 the flexible portion 23 will be completely telescoped into the stationary portion 22 and will be folded around an equatorial bead 24. This bead is provided for two purposes. It reinforces the stationary portion 22 of the bag at the equator to help maintain that portion in contact with the shell 10 at all times. The bead also provides a smooth shoulder about which the flexible portion 23 of the bladder can bend with a substantial radius of curvature to reduce the danger of the material cracking at the fold.

The closed end of the bladder is reinforced with a pair of discs 25 and 26 which are clamped together by a screw 27, the bladder having a small orifice at its end to permit passage of the screw. These discs 25 and 26 are provided to prevent the extrusion of the flexible bladder wall into the liquid opening 11 in case of failure of liquid pressure and into the air passage 15 in the event of failure of the air pressure. The flexible portion 23 of the bladder preferably has a relatively flat end spaced appreciably from the end of the shell when the bladder is in its normal, or unstressed, position. It is found that this construction tends to promote the orderly collapse of the bladder when the liquid pressure is increased, and the orderly distension of the bladder against the wall of the shell progressively from the equator to the opening 11 when liquid is being drawn from the accumulator.

As so far described, the bladder corresponds to those previously known, in which the general shape of the bladder was relied upon to prevent undesired trapping of liquid in pockets formed between the bladder and shell. However, as a result of variations from the desired thickness of the bladder wall due to faulty manufacture, and as a result of reasons which are at present not fully known, bladders of the type described sometimes expand irregularly and in such a manner that the bladder may be forced against the wall of the shell over an area completely surrounding the liquid opening 11 while a portion of the bladder more remote from the opening is still inwardly displaced from the shell. When this happened with the prior known constructions, the pocket trapping the liquid was effectively cut off from the liquid opening 11 so that the volumetric efficiency was reduced.

The present invention resides in the provision of small buttons or bosses 28 on the exterior surface of the flexible portion 23 of the bladder and the provision of a plurality of raised bosses or shoulders 30 on the outer surface of the outer disc 25. The bosses 28 on the bladder contact the shell first and maintain the outer surface of the bladder intermediate the bosses in spaced relation with respect to the shell, so that fluid trapped between the bladder and the shell at a point spaced away from the opening 11 can still flow between the bosses 28 to the opening 11. The shoulders 30 on the outer disc 25 contact the shell when the bladder is fully expanded, leaving the portions 31 of the outer surface of the disc in spaced relation to the shell so that liquid can escape therethrough to the liquid opening 11.

The bosses 28 are preferably arranged in rows extending along meridians of the bladder as shown in Fig. 2. In that figure, the bosses 28 are arranged in short rows 282 and in longer rows 281. The pattern can be varied, but it seems to be unnecessary to make all the rows of full length. Trapping most often results from sealing of the bladder against the shell over an area closely surrounding the opening 11 and it is, therefore, desirable to have the bosses spaced quite close together over this area. However, when the trapping occurs at points adjacent the equator, the liquid is exhausted from the trapping area by the bosses 28 in the long rows 281, even though the rows are spaced relatively far apart.

It is found that the shoulders 30 on the outer disc 25 can rise about .025" above the general outer surface of the disc 25 without making gaps wide enough to damage the bladder wall when full air pressure is applied within the bladder and the liquid opening 11 is opened to the atmosphere. At the same time, the gaps provided by shoulders .025" high permit sufficiently free flow of liquid therethrough. The dimensions of the buttons or bosses 28 are not particularly critical. They may be approximately ¼" in diameter and approximately $\frac{1}{8}$" high and are preferably formed integrally with the bladder wall by the use of a suitable mold. In general, the height of the bosses is of the same order of magnitude as

the thickness of the bladder wall although it is usually somewhat less.

Various patterns of distribution of the bosses may be used. The particular pattern shown in Fig. 2 has been found suitable for a 10" bladder, the long rows **281** being spaced 30° apart with one short row **282** containing two buttons positioned between each adjacent pair of long rows.

On the other hand, on a bladder for a 7½" accumulator, the long rows may be spaced 60° apart, with three short rows of two buttons each spaced between each adjacent pair of long rows.

In a bladder for a 5" accumulator the long rows **281** may also be spaced 60° apart but with only three bosses in each long row, and with three short rows **282** of only one button each positioned between each adjacent pair of long rows. In a bladder for a 10" accumulator the outermost bosses may be spaced radially 3¾" from the axis of the bladder. In the 7½" size the outermost bosses may be spaced 3¼" from the bladder axis, and in the 5" bladder the radial spacing from the axis of the outermost buttons may be approximately 2".

The views of Figs. 3 to 6 illustrate how fluid can be trapped in an accumulator having a bladder without the bosses **28**, and how the bosses prevent the trapping.

Referring first to Fig. 3, the flexible end of the bladder is shown in a shape which it may assume as it is being expanded, in response to withdrawal of liquid through the opening **11**. It will be observed that the bladder has not folded along a circular line but instead has folded in the general shape of a triangle. It is found in practice that the bladders usually fold along an irregular line although not always in three lobes as shown in Fig. 3. Sometimes it may fold in four or five lobes instead of three. The irregular folding probably results chiefly from the fact that the thickness of the bladder wall produces unequal tension and compression in the inner and outer surfaces, but regardless of the exact cause it seems impossible in practice to construct bladders that will telescope in a perfectly symmetrical manner.

As best shown in the section of Fig. 4, the lobular folding of the bladder causes it to approach the shell closely at a point **50** on one side of the liquid opening **11**, while being bulged away from the shell at a point **51** on the other side of the liquid opening. As liquid continues to flow out of the liquid opening **11**, the bladder may contact the shell all around the liquid opening **11**, as shown in Fig. 5, while the portion **51** is still bulged inwardly away from the shell. This results in the formation of a pocket **52** which would be cut off completely from the liquid opening **11** if the bosses **28** were not present. However, the bosses **28** prevent a sealing contact between the bladder and the shell in a zone surrounding the opening **11**, and the liquid therefore has a path of escape out of the pocket. Assuming that the pressure in the liquid opening remains less than the pressure of the air within the bladder, the portion **51** of the bladder will be forced out until all the bosses **28** are in contact with the shell as shown in Fig. 6. By the time all the bosses have contacted the shell very little liquid will be left in the spaces surrounding the bosses. If the liquid drain continues, resulting in a substantial reduction of the pressure in the liquid opening below the air pressure within the bladder, the bladder wall will be distorted to force substantially the entire outer surface of the bladder against the shell except for a very narrow space surrounding each boss, and the liquid that is left trapped in these small spaces is relatively small and unimportant.

Although for the purpose of explaining the invention a specific construction has been described in detail, various changes from the exact construction shown can be made without departing from the invention which is to be limited only to the extent set forth in the appended claims.

I claim:

1. An accumulator bladder for use in an accumulator shell having two spaced fluid openings, said bladder being of flexible material adapted to be secured to the shell adjacent one of the openings and in communication therewith, whereby it constitutes a fluid-tight movable partition within the shell between said two openings, in which at least a portion of the exterior surface of said bladder is provided with a plurality of spaced bosses for initially contacting the shell upon distension of the bladder and providing paths for escape to the other of said openings in the shell of fluid trapped between the bladder and the shell, said bosses being spaced from each other in all directions whereby they provide paths for escape of trapped fluid in a plurality of directions from a trapping area.

2. A bladder as described in claim 1 in which said bosses are located on that portion of the bladder surrounding the said other opening when the bladder is distended against the shell.

3. A bladder for use in an accumulator shell having two spaced fluid openings, said bladder being of flexible material and adapted to be secured to the shell adjacent one of said openings and communicating therewith whereby it constitutes a fluid-tight movable partition within said shell between said two openings, and a rigid reinforcement secured to said bladder at the point therein juxtaposed to the other of said openings in said shell, said reinforcement having an irregular contour along its edge whereby it contacts the shell only at spaced intervals to provide narrow gaps between the reinforcement and the shell for escape of fluid into said other opening when pressed thereagainst, while preventing extrusion of bladder material into said opening.

4. An accumulator bladder for use in a generally spherical accumulator shell having two diametrically opposite fluid openings, said bladder being of flexible material and adapted to be secured to the shell adjacent one of said openings and in communication therewith, a first portion of said bladder adjacent said one opening being formed to fit against the shell and the remaining portion being flexible and adapted to telescope into the first portion when the bladder is collapsed, the telescoping portion of the bladder having a plurality of bosses on its outer surface adapted to surround said other opening for providing passages for the escape to said other opening of fluid trapped between said bladder and said shell by movement of the bladder against said other opening, said bosses being spaced from each other in all directions whereby they provide paths for escape of trapped fluid in a plurality of directions from a trapping area.

5. A bladder for use in an accumulator shell having two spaced fluid openings, said bladder being of flexible material and adapted to be secured to the shell adjacent one of said openings and communicating therewith whereby it consti-

tutes a fluid-tight movable partition within said shell between said two openings, and a rigid reinforcement secured to said bladder at the point therein juxtaposed to the other of said openings in said shell, said reinforcement being configured to define passages for escape of fluid into said other opening when pressed thereagainst, while preventing extrusion of bladder material into said opening, and the portion of the exterior surface of said bladder surrounding said reinforcement having a plurality of spaced bosses thereon for initially contacting the shell upon distension of the bladder and providing paths for escape to the said other opening of fluid trapped between the bladder and the shell.

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