Jan. 17, 1956 F. S. SCHINDLER ET AL 2,731,037

HYDRAULIC ACCUMULATORS

Filed Sept. 23, 1950 2 Sheets-Sheet 1

Fig. 1.

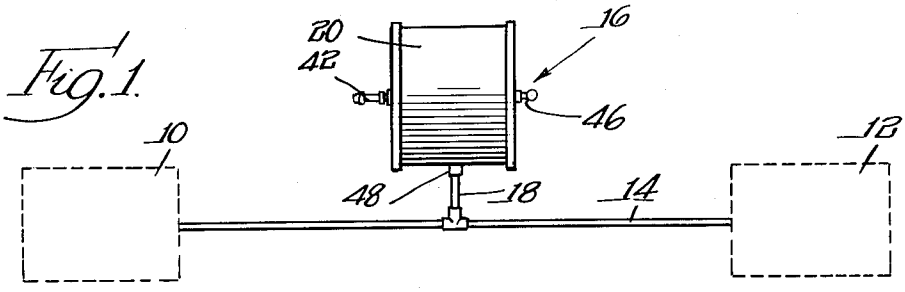

Fig. 2.

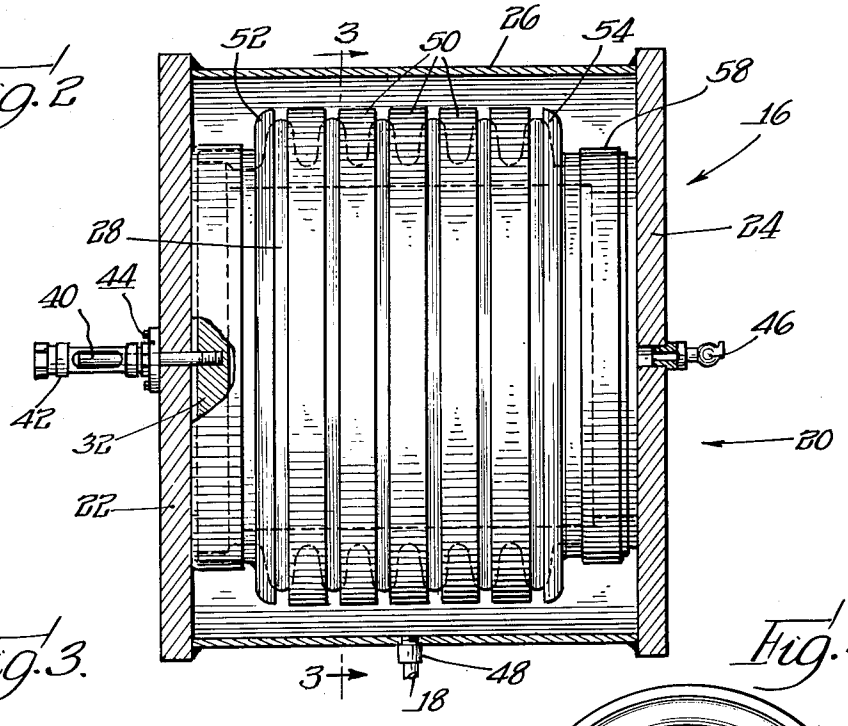

Fig. 3.

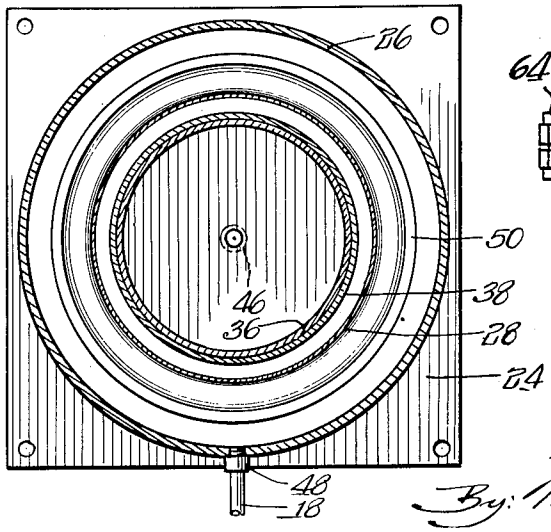

Fig. 4.

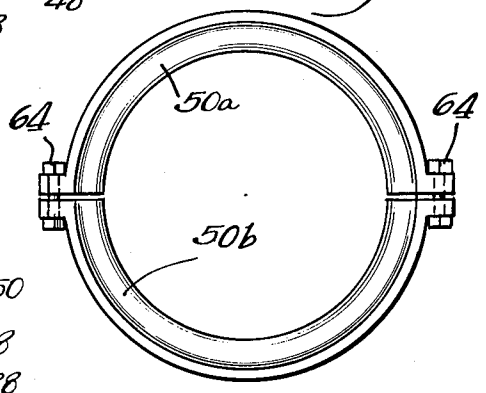

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Fig. 5.

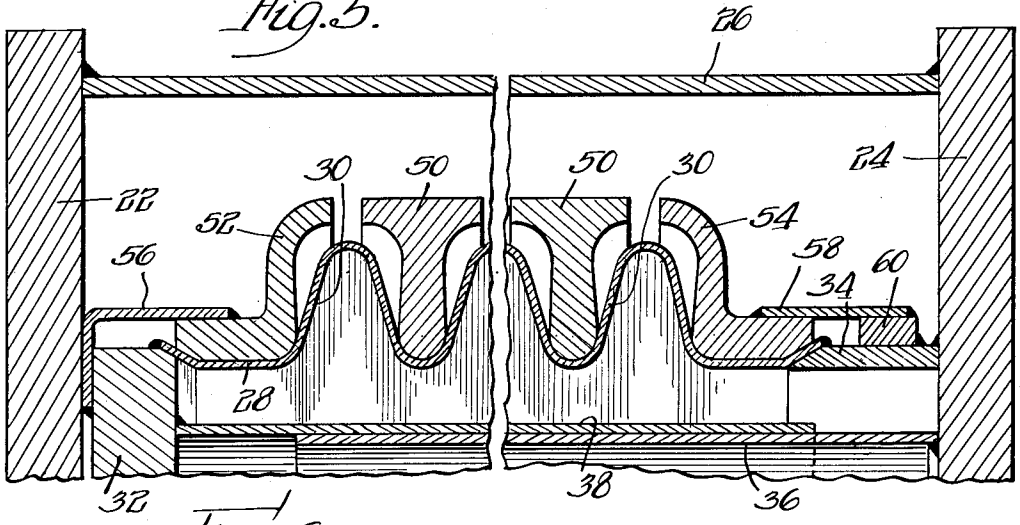


Fig. 6.

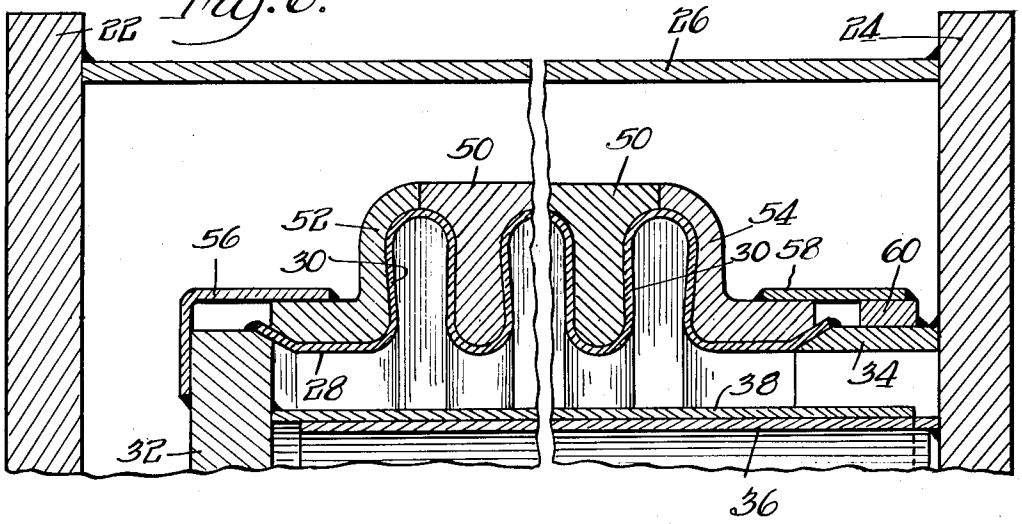
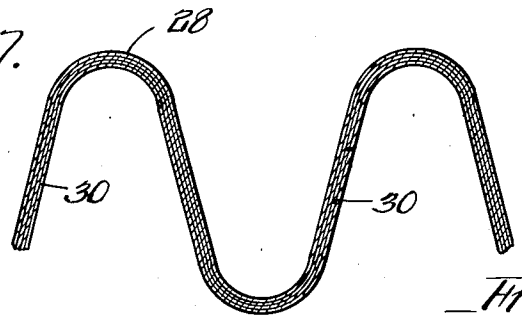


Fig. 7.



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HYDRAULIC ACCUMULATORS

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Application September 23, 1950, Serial No. 186,426

6 Claims. (Cl. 138—30)

This invention relates to hydraulic accumulators, and particularly to hydraulic accumulators and hydraulic accumulator installations, wherein accuracy and durability in the operation of the accumulator are important factors.

Hydraulic accumulators, as conventionally fabricated, comprise expansion chambers, wherein there is disposed a rubber diaphragm or bladder sealing off or otherwise forming within the accumulator a chamber for gas under pressure. The remainder of the accumulator is interconnected with a hydraulic system in such a manner that as the fluid is introduced into the accumulator from the system, the gas within the gas chamber is compressed, the gas thereby acting to maintain the system fluid under pressure while, at the same time, being sealed away from the hydraulic system so that it cannot become commingled therewith.

The rubber diaphragms or bladders of conventional accumulators suffer the disadvantages that the rubber is permeable, at least to a small degree, to the gas or hydraulic system fluid so that over protracted periods inaccuracy results and the gas supply within the sealed gas chamber must be either purified or replenished, as the case may be. Also, the rubber deteriorates with age, and is not suitable for use in many installations wherein high or low temperatures, or corrosive materials, are encountered.

In accordance with the present invention a hydraulic accumulator structure is provided which incorporates a metallic bellows structure in such a manner that it operates to provide a sealed gas chamber within the accumulator. The expansion and contraction of the bellows under the gas pressure control serves to maintain pressure within the associated hydraulic system. Provision is made for enabling the structure to withstand high pressures, for imparting to the bellows or collapsible gas chamber a high degree of flexibility as may be desired, and for indicating the condition and position of the bellows at all times which, when coupled with the nonpermeable characteristic of the structure provides an accurate determination of the associated hydraulic system at all times.

It is accordingly an object of the present invention to provide an improved hydraulic accumulator structure wherein a metallic bellows forms the expansible and contractible accumulator gas chamber.

The further object of the invention is to provide an improved hydraulic accumulator which avoids many of the difficulties encountered with conventional accumulator structures now employed.

More specifically stated, an object of the invention is to provide an improved hydraulic accumulator having improved durability and accuracy in operation, which may be highly flexible, and which may be subjected to high pressures as well as extreme temperatures and corrosive materials.

A further object of the invention is to provide, in a hydraulic accumulator of the foregoing type, an improved

indicator arrangement for indicating the position of the bellows or expansible and collapsible gas chamber.

Various other objects, advantages and features of the invention will be apparent from the following specifications taken in connection with the accompanying drawings, wherein certain preferred structural embodiments are set forth for the purposes of illustration.

In the drawings wherein like reference numerals refer to like parts throughout:

Fig. 1 is an assembly view, diagrammatic in form, of a hydraulic accumulator installation incorporating a hydraulic accumulator structure fabricated in accordance with and embodying the principles of the present invention.

Fig. 2 is an enlarged sectional view of the hydraulic accumulator structure illustrated in Fig. 1.

Fig. 3 is a transverse sectional view of the structure of Fig. 2 taken as indicated by the line 3—3 thereof.

Fig. 4 is a detailed view showing a modified form of pressure ring, as may be used in the present invention.

Fig. 5 is a partial longitudinal sectional view, on an enlarged scale, of the accumulator structure of Fig. 2, the collapsible bellows being shown in expanded or extended condition.

Fig. 6 is a view similar to Fig. 5 but showing the bellows collapsed to its maximum extent; and

Fig. 7 is a further enlarged detailed view showing the character of the bellows wall, as preferably fabricated in accordance with the present invention.

Referring more specifically to the drawings, and first to the embodiment illustrated in Figs. 1–3 and 5–7, in Fig. 1, there is diagrammatically illustrated a hydraulic accumulator installation comprising a pair of machines **10** and **12**, interconnected by a pipe or conduit **14**, and a hydraulic accumulator generally indicated by the numeral **16**. The accumulator may be suitably interconnected with the system at any desired point, for example, as indicated by the conduit or pipe **18**.

In a typical hydraulic accumulator installation, the machine **10** may comprise a pump, and the machine **12** an hydraulic actuator, the accumulator **16** being employed to augment the capacity of a pump by storing up within itself fluid under pressure during pump operation between operating cycles of the hydraulic actuator **12**. In other types of installations, the machines **10** and **12** may comprise devices subjected to varying conditions of temperature, or other operating conditions causing an expansion or contraction of fluid therein, the hydraulic accumulator **16** in such instances operating to receive the excess fluids from the machines **10** and **12**, and to store such fluids and to return them to the machines **10** and **12** under pressure, as may be required. In either event, the hydraulic accumulator acts as a storage reservoir for fluids under pressure, of variable capacity, and of maintained pressure in accordance with a desired pressure condition.

Referring to Fig. 2, the hydraulic accumulator structure more specifically comprises a casing **20** formed of a pair of end plates **22** and **24**, and a casing cylinder **26**, within which is disposed an expansible and collapsible bellows structure **28**.

As best shown in Figs. 5, 6 and 7, the metallic bellows preferably comprises a metallic cylinder or tubular wall having a plurality of parallel annular corrugations **30** resilient and yieldable so as to expand and contract between the operating positions shown in Figs. 5 and 6, as the bellows is subjected to varying pressure conditions. The normal or pre-operating position of the parts is shown in Fig. 5, wherein the inherent resiliency and shaping of the convolutions **30** act to expand the bellows to its maximum degree, as will presently appear. As best shown in Fig. 7, the bellows wall **28** is preferably lami-

nated, viz., formed of a plurality of inter-fitted concentric metallic tubes, so as to provide a multi-ply wall structure. Such multiple ply wall imparts increased flexibility to the tubular metallic wall, in respect to the over-all wall thickness, whereby to provide increased wall flexibility in respect to the pressure resistance of the wall structure, as may, in certain instances, be desirable.

Referring further to Figs. 2, 5 and 6, it will be seen that the outer end of the tubular wall **28** is secured by welding or other suitable means to a cap member **32**, the cap member with the tubular wall **28** thus forming a cup-shaped bellows within the accumulator casing formed by the casing end walls **22**—**44** and side wall **26**; in a manner so that an increase in pressure within the accumulator casing tends to collapse the bellows from its expanded position, as shown in Fig. 5, to a collapsed position, as indicated in Fig. 6. The inner or stationary end of the tubular wall **28** is welded or otherwise suitably secured to a nipple piece **34**, which is, in turn, anchored to the casing end wall **24** by welding or other fluid tight seal. A stationary guide sleeve **36** is secured to the casing end wall **24**, and a cooperable, shiftable guide sleeve **38** is secured at its end to the cap member **32**, the loosely interfitted guide sleeves **36** and **38**, thus comprising a guide structure for constraining the bellows for aligned longitudinal shifting within the accumulator casing.

An indicator rod **40** is threadedly inter-connected with the cap member **32**, so as to shift therewith, this indicator rod being shiftable within an indicator casing **42** which is carried by the stationary casing plate **22**, so that the position of the indicator rod within the indicator casing provides an external indication of the condition or position of the bellows structure. As will be understood, the indicator rod **40** is shiftable within the stationary casing plate **22**, suitable packing being provided as indicated at **44** in association with the indicator casing **42**, so as to provide a fluid-tight joint.

Gas under pressure may be introduced into the interior of the bellows through a fitting **46**, Fig. 2, a suitable tapped opening, and associated check valve, being carried by the casing plate **24**, for this purpose.

The hydraulic fluid from the associated hydraulic system may be introduced into the accumulator casing from the pipe **18**, by means of a fitting **48**, Fig. 2, associated therewith.

In accordance with the present invention, provision is made for enabling the collapsible bellows to withstand high operating pressures. To this end, there is provided a series of intermediate reinforcement rings **50**, one for each corrugation of the tubing **28**, in embracing relation therewith, and a pair of end reinforcement rings **52** and **54**, also in embracing relation with the tubing wall and adjacent the opposite ends thereof. The rings **50**, **52**, **54** may be variously formed and applied to the corrugations of the tubular wall, but preferably these rings are of the type and applied in the manner more specifically disclosed in the co-pending application of Frank S. Schindler and Richard K. Titus, Serial No. 8,116, filed February 13, 1948, now Patent No. 2,644,487, July 7, 1953, and entitled "Reinforced Flexible Conduit and Method of Manufacture." More particularly, as specifically disclosed in said application, the rings are of integral annular construction, and are applied to the tubing prior to the corrugating thereof, and while the tubing is of cylindrical form. The rings are applied to the tubing in predetermined spaced relation after which hydraulic pressure is applied internally of the tubing so as to cause deformation of the tubing wall and the formation thereof into a series of annular corrugations, the integral rings acting as die members to control the forming operation. After the forming, the rings become permanently associated with the tubing in embracing relation, respectively, with the several corrugations thereof.

As best shown in Figs. 5 and 6, the rings are internally shaped and spaced a predetermined distance apart so that, upon contraction of the bellows, the contours of the rings become inter-fitted with the contours of the tubing corrugations, the ring edges coming into abutment to limit the contracting movement.

The reinforcement rings provide high pressure resistance to the bellows, enabling the corrugated tubing wall to be highly resistant to differential fluid pressures internally and externally of the bellows.

To further stabilize the structure, and enable the proper alignment of the reinforcement rings and bellows corrugations, the outer end ring **52** is suitably secured, as by welding or the like, to a fitting **56** anchored to the end cap **32**; whereas the inner end ring **54** is secured to a cylindrical fitting **58**, the latter being in turn anchored to an annular fitting ring **60** carried by the casing nipple **34**.

In the operation of the structure, gas at suitable pressure is introduced into the interior of the bellows through the fitting **46**. As hydraulic fluid enters or is withdrawn from the casing **20** through conduit **18** in the operation of the associated hydraulic system, the bellows is contracted against the gas pressure or expanded thereby between its Fig. 5 and Fig. 6, and intermediate positions. The gas pressure within the bellows will remain undiminished, and at its original preset value, substantially indefinitely as the bellows structure is completely gas and fluid tight. Also there is no gravitation or loss of the fluid within the hydraulic system into the bellows gas chamber. The laminated wall structure of the bellows tubing renders the bellows more responsive to small pressure changes, while, at the same time, providing a rugged and pressure resistant tubing wall. Also the laminated character of the wall structure increases its fatigue life. In instances wherein a less sensitive pressure response may be desired, a compression spring may be inserted to the bellows structure, as will be understood.

The pressure rings further increase the pressure resistivity of the bellows, permitting a wide pressure differential interiorly and exteriorly. The guide structure **36**—**38** predetermines the path of motion of the bellows, and further aids in preventing it from becoming distorted when subjected to high pressure conditions. As will be understood, the metal of the bellows and of the other operating parts may be selected to resist corrosion by the fluids of the associated hydraulic system, and the structure may be used under extremely high or low temperatures without deterioration. The indicator **40**—**42** provides an indication of the relative pressure conditions within the accumulator, at all times. If desired, as will be understood, a pressure gauge may be associated with the fitting **46** so as to indicate the charging or internal pressure of the gas within the bellows.

In Fig. 4 a ring structure is illustrated wherein the reinforcement rings, functionally corresponding to the rings **50**, **52**, and **54**, previously described, are made in two parts as indicated at **50***a* and **50***b* bolted together by bolts **64**. This arrangement permits the rings to be applied to the bellows after the formation of the bellows corrugations, and this arrangement may be used in instances wherein it is desired to render the rings removable, or in instances wherein the corrugations in the bellows tubing may be formed other than as hereinbefore described.

It is obvious that various changes may be made in the specific embodiments set forth for purposes of illustration without departing from the spirit of the invention. The invention is accordingly not to be limited to the specific structural embodiments shown and described, but only as indicated in the following claims.

The invention is hereby claimed as follows:

1. A hydraulic accumulator comprising a casing arranged to form a chamber adapted for connection with a hydraulic pressure system, and an expansible metallic bellows disposed within said chamber and arranged to form an expansible gas container therein, said bellows comprising a plurality of concentric tubing sleeves annularly corrugated at predetermined intervals to form a

laminated corrugated tubing wall structure, said tubing wall structure being secured at one end to a fixed wall of a casing chamber, and being freely movable within the casing chamber at its other end, a pressure cap member secured to the free end of the tubing wall, intermediate reinforcing rings embracing the tubing wall and anchored respectively within the several corrugations thereof, end reinforcing rings surrounding an adjacent end of the tubing with one of said end reinforcing rings clamping the tubing against said cap member and with the other of said end reinforcing rings clamping the other end of the tubing, guide means comprising a pair of telescoping sleeves secured respectively to the fixed casing wall and to said pressure cap, whereby upon variations of fluid pressures within the casing chamber, the cap member and associated free tubing wall end is shifted thereby under control of said guide means, and means for connecting the chamber with a line of a hydraulic system, said connecting means communicating with said chamber at a point offset radially from the bellows to prevent the bellows from blocking the connecting means.

2. A hydraulic accumulator, comprising a casing providing a chamber adapted for connection with a hydraulic pressure system, a length of corrugated tubing disposed within said chamber, plate means at each end of the tubing for closing the tubing to provide an expansible gas container, at least one end of said tubing terminating in a conical portion mating with a bevelled surface on its associated plate means, means providing a hermetic seal between said conical portion and its associated plate means, a ring member overlying the tubing and conical portion for clamping said conical portion against said bevelled surface, and means for maintaining the ring member in its clamping position whereby to prevent the application of any undue stresses to said seal.

3. A hydraulic accumulator as claimed in claim 2 wherein the means for maintaining the ring member in clamping position comprises an end fitting secured to the adjacent plate means and to said ring member.

4. A hydraulic accumulator comprising a casing including end walls and forming a chamber for connection with a hydraulic pressure system, a corrugated metal

bellows tubing disposed within said casing and providing an expansible gas chamber, means securing one end of said bellows tubing to the adjacent end wall of the casing and including an adapter member fixed to the said casing end wall and a ring member overlying the tubing and adapter member for clamping the tubing therebetween, a closure for the opposite movable end of the bellows tubing, and telescoping guide tubes concentric with the bellows tubing, one of said tubes being fixed to the end wall of the casing carrying the adapter member and the other of said guide tubes being secured to said closure for supporting the bellows tubing against axial distortion during movement thereof within the casing.

5. A hydraulic accumulator as claimed in claim 4, wherein there is provided a ring member for clamping the movable end of the bellows tubing against the closure at the movable end.

6. A hydraulic accumulator as claimed in claim 4, wherein end ring members overlie the ends of the bellows tubing, one ring member clamping the tubing against the closure and the other ring member clamping the tubing against the adapter member, and wherein annular end fittings are provided for holding the ring members in their respective clamping positions.

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