

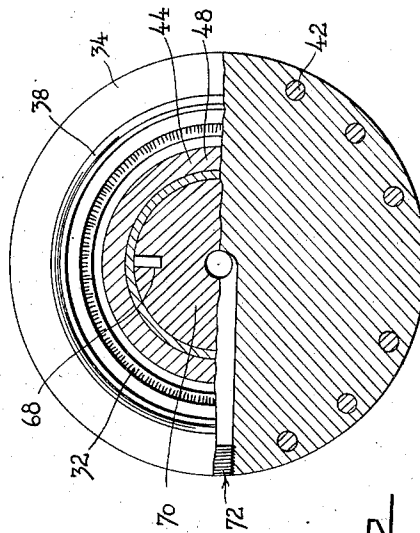
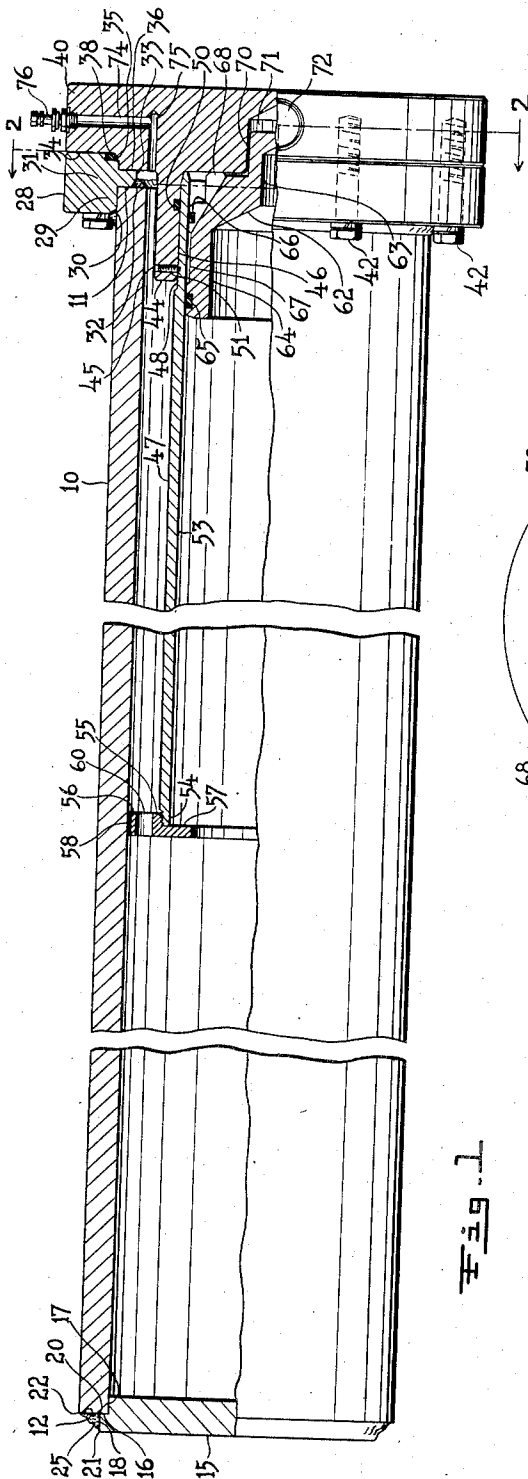
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ACCUMULATOR

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ACCUMULATOR

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This invention relates to an accumulator and particularly to a mechanical accumulator of the gas-liquid type for storing mechanical energy. As is well known, an accumulator of this type customarily has a rigid metallic container having a fixed volume. This container is divided into two separate chambers by a movable partition such as a floating piston, for example. On one side of the partition is a liquid storage chamber and on the other side of the partition, hermetically sealed to atmosphere, is a gas storage chamber. A fluid line provides communication between the fluid storage region and the accumulator load whereby the accumulator may be charged for storage of energy and discharged to operate a load.

All of the energy stored in an accumulator is stored within the gas chamber in the form of compressed gas. The greater the quantity of gas that is available for compression and the greater the pressure differential between a loaded and unloaded accumulator, the greater is the energy storage capacity of an accumulator. For all practical purposes, the liquid within the accumulator, usually oil, will be considered as incompressible. Hence as oil is supplied to the oil chamber in the accumulator under sufficient pressure, the piston or partition separating the oil from the gas chambers will be forced to move for effecting compression of the gas. The increase in gas pressure due to movement of the piston will be a function of the change of gas chamber volume with respect to piston movement. By controlling the maximum and minimum volumes of gas within the accumulator corresponding to extreme piston positions and also by controlling the shape of the gas storage region, a wide type of control will be exercised over the final accumulator characteristics.

Apart from different characteristics that may be desired in accumulators, there is additionally the factor of the overall accumulator volume which determines the maximum storage capacity of the accumulator. Thus for certain applications where no great amount of energy storage is required, accumulators having a volume of the order of a few cubic inches may suffice. An example, an accumulator having an effective volume of about 10 cu. in. may have a length of about 6" and a diameter of about 2", these dimensions being outside dimensions. For heavy duty applications, accumulators having a diameter of as much as 12" or more and a length of the order of 5 ft. or more are desirable. Such heavy duty accumulators may be used for starting diesel engines in extremely cold regions and may be used for other heavy duty applications.

Due to the wide field of use for accumulators, it is desirable to be able to have a wide range of accumulator capacities by the simple expedient of controlling the length of the accumulator only. In order to make full use of such a flexibility of accumulator design, it is also desirable that all machine work and finishing operations be concentrated at one end of the accumulator only, thus leav-

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ing the other end of the accumulator free to change as desired.

It is well known that accumulators operate at extremely high pressures up to as much as about 6,000 lbs. p. s. i. so that finishing operations for accumulators involve accurate machine work and require close tolerances. The desirability of being able to make an accumulator of indefinite length, coupled with the fact that finishing and machining operations on an accumulator are precision operations and are inherently expensive and that the vast majority of machine tools can operate over only limited and comparatively short lengths of material, makes it all the more desirable for concentrating all the finishing operations at one end of an accumulator.

This invention provides an accumulator construction wherein substantially all of the finishing operations are concentrated at one end of the accumulator and thus makes possible flexibility of accumulator design with regard to accumulator length. For a more thorough understanding of the invention, reference will now be made to the drawing wherein an exemplary embodiment is illustrated. It is understood, however, that variations may be made all within the scope of the invention as defined by the appended claims.

On the drawings:

Fig. 1 is a side elevation, with parts broken away and in section, of an accumulator of the present invention, and Fig. 2 is a sectional view taken along the planes 2—2 of Fig. 1.

The accumulator embodying the present invention has outer shell 10 of steel pipe having ends 11 and 12 respectively. Shell 10 may have any desired length and any desired diameter. As an example, shell 10 may be of steel tubing having an outer diameter of 12" and a 1" wall. Shell 10 may either be seamless or of the welded variety or may be fashioned in any desired manner, it being understood, however, that the shell has sufficient strength for withstanding the maximum accumulator pressure. Inasmuch as steel tubing or pipe comes in long lengths and may even be welded to form a number of lengths, outer shell 10 may therefore have any desired length. In the example given above, a steel tube having a 12" outside diameter is obtainable in 25 ft. lengths.

End 12 of shell 10 is hermetically sealed by end plate 15. End plate 15 is also preferably of steel and should be heavy enough so that the plate will not buckle. While end plate 15 may be rigidly attached to end 12 of shell 10 in any desired manner and may have any desired fit, it is preferred to have end plate 15 provided with radial shoulder 16 connecting annular surfaces 17 and 18 respectively of the disc. It is not necessary to have an accurate fit between annular portion 17 of the end disc and the inside surface of shell 10 adjacent end 12. The width of radial shoulder 16 (the dimension radially of disc 15) is such that annular surface 18 of the disc comes short of the extension of the outer surface of shell 10. A convenient and desirable design provides for the width of annular band 18 to be about equal to the portion of the thickness of the wall of shell 10 extending beyond band 18. Thus considering a section, if point 20 is at the intersection of a line transversely of band 18 and a line on end 12 outwardly and radially of the shell wall, then points 20, 21 and 22 as indicated will be the corners of an isosceles triangle. Point 21 is at the very end of disc 15 while point 22 is at the very end of the shell wall. It is understood, of course, that the locus of points 20, 21 and 22 around the outer shell of the accumulator will be three concentric circles. Sides 20 to 21 and 20 to 22 are the two sides of the triangle as seen in section which are approximately equal in length.

With end plate 15 positioned as illustrated, weld 25 is made around the end of the pipe. Weld 25 has a generally triangular cross-section and fills the triangle between points 20, 21 and 22. The shape of the weld between points 21 and 22 around the entire length of the weld is unimportant within wide limits and the weld may either be concave or convex as seen from the outside.

Referring now to end 11 of outer shell or tube 10, this end may be finished or not, as desired. Preferably, this end is cut clean. Disposed around end 11 of shell 10 is flange ring 28 of steel. Ring 28 has portion 29 which is disposed immediately around the outside of shell 10 near end 11. Portion 29 should cover a sufficient part of the end of shell 10 so that a firm anchorage on the shell is secured. Thus portion 29 may cover about a one-inch length of shell 10. Portion 29 is chamfered at 30. Flange ring 28 also has portion 31 thereof which lies against end 11 of shell 10. Portion 31 of the flange ring is chamfered at 32, the chamfer and inner edge 33 of portion 31 being short of the inside surface of shell 10. Flange ring 28 has welds at chamfers 30 and 32, the welds forming a continuous junction between the flange ring and the outside and end faces of outer shell 10. Preferably, the opposed surfaces between the outside of shell 10 and the inside face of portion 29 of the flange ring are machined to an accuracy of the order of about a thousandth of an inch.

Flange ring 28 has end face 34 terminating in stepped shoulders 35 and 36. The end face and stepped shoulders are accurately finished. Disposed at shoulder 35 is O-ring 38 of suitable compressible material such as synthetic rubber or any other material having desirable gasket properties.

Cooperating with flange ring 28 is end plate 40. End plate 40 is machine to have faces which match face 34 and stepped shoulders 35 and 36 of the flange ring, the flange ring and end plate being shaped to accommodate O-ring 38. It is understood that the dimensions of the various shoulders on the flange ring and end plate are such that O-ring 38 is tightly compressed when the flange ring and end plate are in tightly assembled condition. End plate 40 is maintained rigidly against flange ring 28 by a series of bolts 42 extending through suitable apertures in flange ring 28 and engaging suitably threaded recesses in end plate 40. Bolts 42 are disposed circularly around the axis of the accumulator. It is understood that bolts 42 may, if desired, extend completely through both the flange ring and end plate and have nuts at the ends thereof.

End plate 40 has sleeve 44 extending laterally from the inside surface of the plate—the side which is disposed within the accumulator. Sleeve 44 has outer surface 45 thereof lying within the inside surface of shell 10. Outer surface 45 of the sleeve may be machined or not, as desired, there being no accuracy requirements within wide limits. Sleeve 44 has inner surface 46 which is accurately machined. The thickness of sleeve 44, that is, the distance between surfaces 45 and 46, may be as desired and may, for example, be about the same as the wall thickness of outer shell 10.

Snugly disposed within sleeve 44 is inner shell 47. Inner shell 47 has end portion 48, most of which lies within sleeve 44, accurately finished. The clearance between the outer surface of portion 48 and inner surface 46 of the sleeve is preferably small, of the order of about a thousandth of an inch and is just enough so that the reduced portion 48 of shell 47 may be inserted within the sleeve. Sleeve 44 has an internal annular groove 50 cut out therefrom and within this groove there is disposed an O-ring of suitable material. Thorough sealing against leakage between the liquid and gas chambers is provided principally by the O-ring in annular groove 50. Sleeve 44 has set screws 51 disposed in threaded apertures there-through, the set screws engaging indentations or recesses in the outer surface of reduced portion 48 of inner shell

47. The set screws are provided to lock inner shell 47 into position and prevent movement of the inner shell with respect to sleeve 44. Other locking means instead of set screws may be provided for locking inner shell 47 against removal from sleeve 44.

Inner shell 47 is also of steel tube. Inner shell 47 has no pressure differential across the wall thereof so that within wide limits, the thickness of the tube wall is unimportant. It is understood that rigidity and general mechanical considerations require sufficient wall thickness so that the tube may function properly. In addition, any increase in the wall thickness of inner shell 47 will result in less space being left for compressible gas so that the thickness of inner shell 47 may be considered as one of the factors having some effect upon the general characteristics of the accumulator. Thus as an example, with outer shell 10 having the dimensions previously given, inner shell 47 may have an outside diameter of about 7" and may have a wall thickness of the order of about 3". Inner shell 47 is made of steel and has inner surface 53 ground or honed to a smooth finish. The important and essential feature is that inner surface 53 must be smooth so that a floating piston may travel up and down the surface and make possible a seal which will hold against pressures encountered in the accumulator. Inner shell 47 may be as long as desired and in practice the length will be limited by the ability of honing equipment. Thus inner shell 47 may have an overall length of about 60" and 70". With proper honing equipment, it is possible to have inner shell 47 longer if desired. In all cases, however, the inner shell is disposed within the outer shell and while not essential, the two shells are coaxial.

Inner shell 47 has its end 54 externally threaded at 55. End 54 is supported by annular member 56 having a threaded portion thereon for engaging the threaded end of shell 47. Annular member 56 has inwardly extending stop portion 57 as an inwardly extending flange at the end of shell 47. Annular member 56 has portion 58 which is generally cylindrical and is just small enough to fit within the inside surface of outer shell 10. Annular member 55 has a number of passages 60 axially of the accumulator, passages 60 being disposed within the space between the opposed faces of the inner and outer shells. Passages 60 are provided for free communication of gas on opposite sides of annular member 55.

Operating within the inner shell is floating piston 62 having head portion 63 and skirt portion 64. Skirt portion 64 has a pair of spaced annular grooves 65 and 66 within which are disposed O-rings for sealing. For example, in groove 65 there may be disposed a combination of different rings for thorough sealing while in groove 66 there may be a simple O-ring for bearing purposes. Any desired arrangement of sealing rings may be provided. Skirt 64 of the floating piston has undercut portion 67 between the two annular end portions of the skirt where the O-rings are located. Undercut portion 67 has a substantial clearance with respect to inner surface 53 of the inner shell. It is understood that the end portions of skirt 64 containing the O-rings are machined accurately to work smoothly within the polished inner surface of inner shell 47.

Floating piston 62 has a generally stepped shape on the outside and a tapered inside surface at the portion between skirt 64 and head 63. Oil relief slot 68 is provided through the body of the floating piston to connect undercut region 67 and the oil side of the piston, this being the side of the piston facing end plate 40. Head portion 63 is finished to provide a generally circular outer face 70 adapted to lie within recess 71 in end plate 40. Communicating with recess 71 in end plate 40 is oil port 72 extending radially of the end plate. In many accumulators, an oil port is provided axially of end plate 40. As illustrated here, however, oil port 72 extends laterally or radially of end plate 40, the oil port extending from recess or chamber 71 to the outer

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surface of end plate 40. The oil port is preferably internally threaded to accommodate a fitting for connecting the accumulator with its load.

In order to charge the accumulator, blind recess 74 extending radially of end plate 40 communicates with blind recess 75. The two recesses 74 and 75 intersect within the body of end plate 40, recess 75 extending generally longitudinally of the accumulator and terminating at the inside face of end plate 40 at the region between external surface 45 and the inside face of shell 10. Valve 76 of any desired construction is rigidly secured to end plate 40 at the end of channel 74. Valve 76 may be of any suitable construction and is adapted to permit of the introduction of any inert gas such as nitrogen, for example, or carbon dioxide, into the gas region of the accumulator. Valve 76 will maintain the gas sealed within the accumulator and in order to avoid the possibility of valve leakage, a suitable cap may be provided over the valve.

Floating piston 62 has a sufficiently long skirt 64 axially of the accumulator so that the floating piston will have substantially no tendency to cock. Thus the axial distance between the sealing rings in grooves 65 and 66 of the skirt may be about one-half of the total length of the piston as measured axially of the accumulator from the outer end of the skirt to the end face of the head. Furthermore, the axial distance between the sealing rings in grooves 65 and 66 will be great enough so that the piston as a whole may ride along the entire length of the inner surface of inner shell 47 smoothly. The combination of the sealing rings and the polished inner surface of shell 53 will provide thorough sealing between the gas and liquid chambers. Stop portion 57 of annular ring 55 at the end of inner shell will cooperate with the end of the skirt portion of the piston to prevent further movement of the piston. It will be clear that any force by floating piston 62 against stop portion 57 will result in a tensile force on inner shell 47 tending to pull the same from inside of skirt 44. It may therefore be necessary to provide heavy locking means at sleeve 44 to maintain inner shell 47 in position against any tendency to pull the inner shell out.

It will be apparent that apart from the honing operation upon the inside surface of inner shell 47, all precision machine work upon the stationary portion of the accumulator is concentrated at one end, this end having the flange ring and end plate. The floating piston, of course, requires some accurate work but the dimensions of the piston, as a rule, are small enough so that it may be handled with little difficulty.

In practice, the ducts or conduits for liquid will lie within the end plate. The gas ducts may also lie within the end plate or a hole may be drilled and tapped for an air valve through the flange ring and outer shell or outer shell alone.

It is apparent that a wide variety of accumulators may be manufactured by control of the length of the inner

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or outer shells or both, assuming that the various diameters are kept constant. Thus the same tooling and machine work upon the flange ring and end plate may be accomplished and a large stock of such accumulators may be kept on hand without danger of freezing an accumulator inventory to one particular capacity or type.

What is claimed is:

1. In an accumulator of the liquid-gas type having concentric inner and outer sleeves of variable lengths to vary the liquid and gas capacity thereof, the outer sleeve being closed at one end and the inner sleeve being open at both ends, standard fittings adapting the sleeves to accommodate the operation of a free-floating piston in the inner sleeve, comprising an end plate secured to the open end of the outer shell and the adjacent end of the inner shell, said end plate having means communicating with the inner shell and with the annular space between the sleeves, and means secured to the other end of the inner sleeve to restrict said other open end thereof for preventing the escape of the piston from the inner sleeve, said last named means also contacting the inner periphery of the outer sleeve to center the inner sleeve therein.

2. In an accumulator of the liquid-gas type, an outer shell having one end closed and the other end opened, a closure plate sealingly engaging the open end of said outer shell, an inner sleeve generally concentric with said outer shell and spaced peripherally therefrom, means sealing one end of said sleeve to said plate and preventing relative axial separation therebetween, a piston reciprocable in said sleeve, and an annular ring secured to the other end of said sleeve, said ring having a radially outwardly extending projection engaging the interior surface of said outer shell to center the sleeve therein and a radially inwardly extending projection lying in the path of movement of the piston to prevent displacement of said piston from said sleeve, the abutment of the piston with said ring subjecting said sleeve to an axial tensile force.

3. In an accumulator of the liquid-gas type having an outer shell sealed at one end and closed at the other end by an end plate, the improvement of an inner cylindrical sleeve having one end secured to the end plate and its other end terminating short of the shell at one end, a piston disposed in the sleeve for free axial movement therein, and an annular ring at the other end of the sleeve extending radially outwardly to locate the sleeve other end concentrically within the shell and extending radially inwardly to restrict the other end of the sleeve to prevent displacement of the piston from the sleeve.

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