

[54] **DIAPHRAGM STRUCTURE FOR DISPENSING FLUIDS**

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[58] Field of Search **222/386.5, 95; 158/50.1; 239/323**

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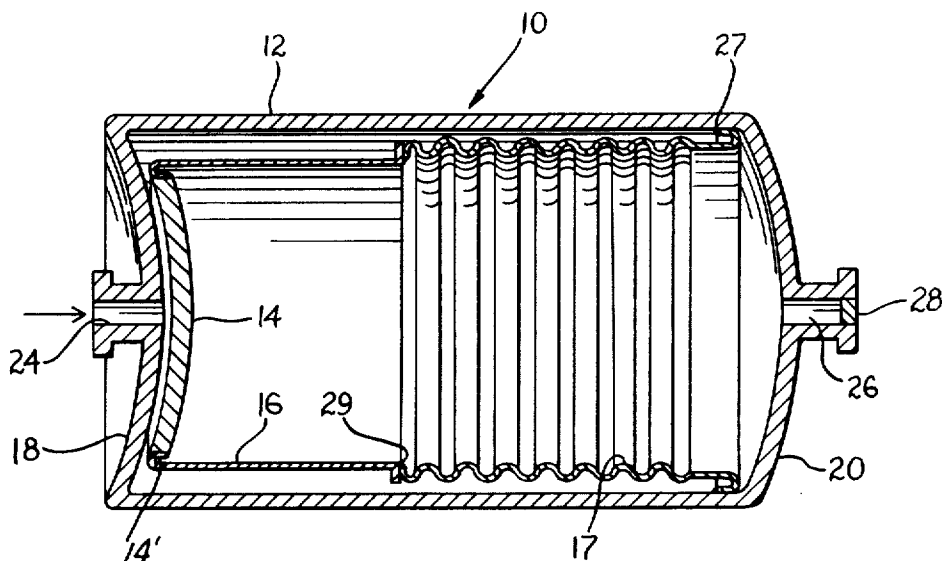
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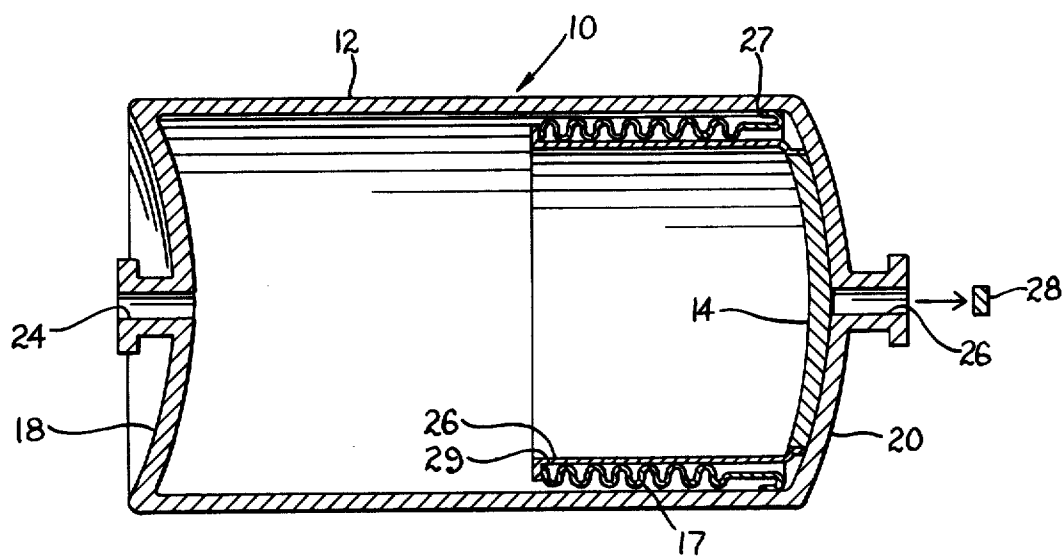
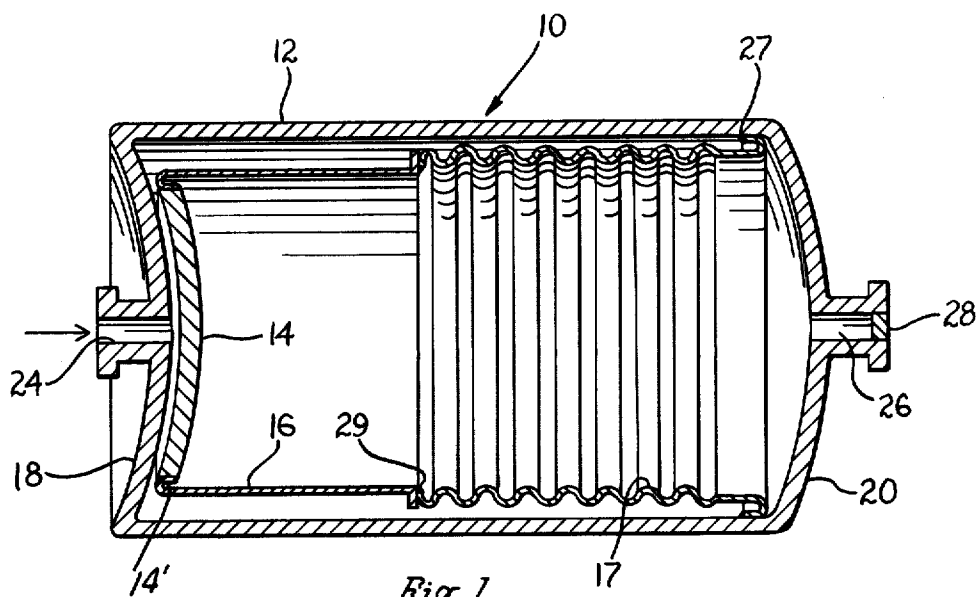
Primary Examiner—Verlin R. Pendegrass

[57] ABSTRACT

Disclosure relates to a construction for positively displacing fluid in a tank and comprises a cylindrical lining for the tank having one end attached to the tank wall, a corrugated section to resist radial buckling and a plain section having one end attached to the corrugated section and its opposite end connected to a piston and in which the plain section rolls inside out in the corrugated section to expell liquid from the tank.

6 Claims, 4 Drawing Figures





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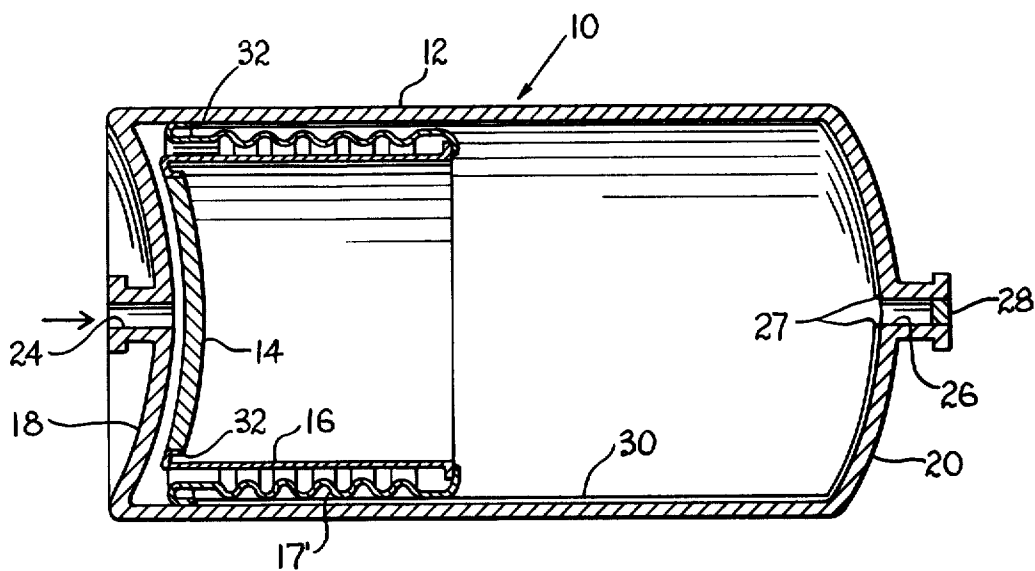


Fig. 3

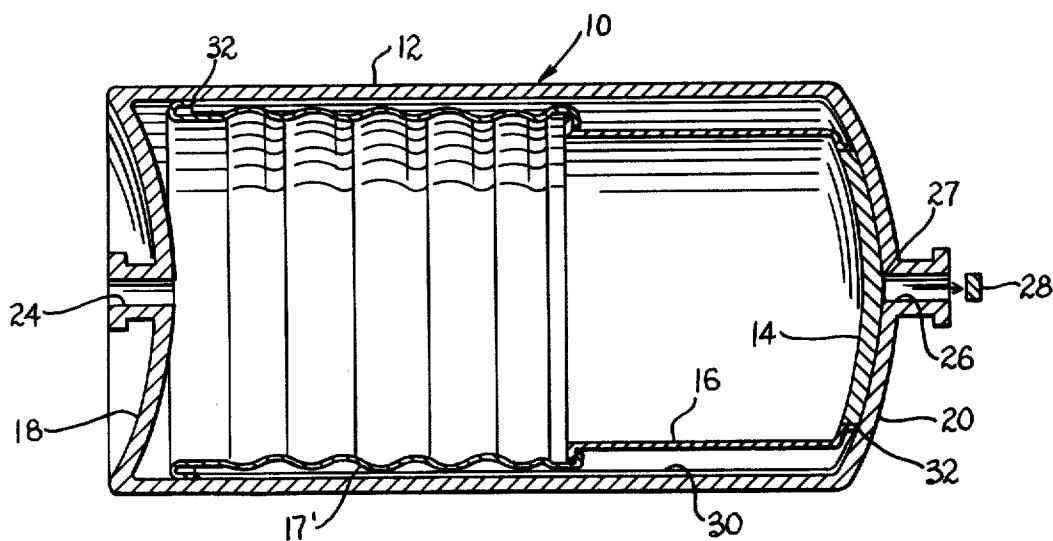


Fig. 4

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DIAPHRAGM STRUCTURE FOR DISPENSING FLUIDS

This invention relates generally to positive displacement, liquid expulsion systems in which a rolling diaphragm or bellows is hermetically sealed to the liquid containing tank and to a piston therein to separate the liquid and a pressurizing gas, the piston being propelled by the gas pressure through the tank to expel the liquid, and relates more particularly to an improved diaphragm-bellows construction.

Diaphragms and bellows of this general type are particularly useful in the liquid propellant expulsion systems of packaged liquid rocket engines. Rolling diaphragms are preferred because they effect nearly complete displacement of the liquid whereas a bellows, which has no buckling problems, affords only partial displacement since a sizeable volume is contained under the solid height of the bellows when fully collapsed. However, the usefulness of rolling diaphragms has been limited in that their flexibility decreases as their size (diameter, length and gauge) increases to accommodate greater propellant volumes.

Analytical and experimental work has shown that the cylinder length of the diaphragm is limited by the fact that the same pressure which acts on the piston to move it and roll back the diaphragm, also acts radially on the cylinder. Frequently this pressure exceeds the buckling strength of the cylindrical diaphragm and instead of being rolled back, the diaphragm buckles. Thus, it is essential in order to avoid buckling of the diaphragm, that the pressure which produces the piston movement must be less than that of the critical buckling pressure of the diaphragm. While a reduction in the length of the diaphragm will increase its resistance to buckling, it also decreases its liquid capacity.

Accordingly, the main object of the present invention is to provide an improved positive displacement, liquid expulsion apparatus which obviates the above and other problems arising from the individual use of bellows or rolling diaphragms.

An important object of the present invention is to provide an improved apparatus having a diaphragm of the type described in which its buckling resistance is increased by reducing its length and by combining it with a bellows so that the liquid contained within the bellows when in collapsed position, is expelled by the diaphragm which moves therewithin so as to eliminate the partial liquid displacement problem.

Another important object of the present invention is to provide an improved positive displacement, liquid expulsion apparatus in which the liquid to be expelled is completely encapsulated so as to avoid any incompatibility between the liquid and the tankage materials.

Other objects and advantages of the invention will become apparent during the course of the following description.

In the drawings, two embodiments of the invention are shown. In these showings:

FIG. 1 is a central vertical sectional view of one embodiment of the invention showing the liquid expulsion apparatus in the storage position;

FIG. 2 is a similar view thereof in the liquid expelled position;

FIG. 3 is a view similar to FIG. 1 of another embodiment of the invention; and

FIG. 4 is a view thereof in the liquid expelled position.

Referring to the drawings, numeral 10 designates as a whole a positive displacement, liquid expulsion apparatus which comprises a cylindrical tank 12, a piston or the closed end 14 of a thin, rolling cylindrical diaphragm 16, and a bellows 17.

The tank 12 is provided with ends 18 and 20 with the former having an inlet 24 for the admission of a gas or other pressurizing medium into the tank to act on the piston or closed end 14 of the diaphragm 16 and force it through the tank 12, the diaphragm 16 and the bellows 17 to abut the other end wall 20 which is provided with a liquid discharge port 26 which may be provided with a burst disc, etc. 28.

One end of the bellows 17 is hermetically sealed to the tank 12 around the port 26 as at 27 so as to eliminate any problem of material compatibility between the tankage materials and the contained liquid (propellant) by isolating them. Also, the open end of the diaphragm 16 is hermetically sealed to the other end of the expanded bellows 17 as at 29 so that the liquid or propellant is completely encapsulated therewithin. Thus, the described structure permits a wide selection of tank materials having an optimum of tankage constructability characteristics.

The closed diaphragm end or piston 14 may be formed integrally with the rolling diaphragm 16 or it may be separately formed of aluminum or other lightweight metal to which the diaphragm is hermetically sealed as indicated in full lines at 14' in FIG. 1. It is to be noted that the piston or closed diaphragm end 14 and the diaphragm 16 is of slightly lesser diameter than the bellows 17 which in turn is of slightly lesser diameter than the tank 12.

In operation as illustrated by FIGS. 1 and 2 which respectively show the initial and final positions of the expulsion apparatus 10, pressure fluid from a suitable source is admitted to the tank 12 by way of the inlet port 24 to act against the closed end or piston 14 of the cylindrical diaphragm 16 to move it toward the tank end 20 to expel the liquid in the tank through the discharge port 26 when the built-up pressure bursts the disc 28.

As the piston 14 moves toward the tank end 20 expelling the liquid contained in the tank-enclosed diaphragm-bellows combination, the thin flexible diaphragm 16 is rolled back 180° within the bellows which is also undergoing a contraction, to the position illustrated in FIG. 2 wherein the bellows 17 is fully retracted and the diaphragm end or piston 14 has moved adjacent the tank end 20 and expelled the liquid within the contracted folds of the bellows through the discharge port 26.

The embodiment and the operation of the invention disclosed in FIGS. 3 and 4 is identical to the foregoing with two exceptions so that identical parts bear identical numerals. In order to obtain complete encapsulation (for tank material compatibility) of the liquid in this embodiment, a tank liner (of metal, non-metal, etc.) membrane 30 is employed and hermetically sealed to the discharge outlet 26 at 27 as before and at 32 to which point the upper end of the fully collapsed bellows 17' is also hermetically sealed. The rollable diaphragm 16 as before is sealed at its lower end to the (lower) end of the bellows 17'.

In operation, the pressurizing gas or fluid acts on the piston 14 and rolls back the thin flexible diaphragm from the position shown in FIG. 3, through the contracted bellows 17' toward the tank end 20. As the movement continues, the bellows 17' is extended so that it and the diaphragm 16 assume the position shown in FIG. 4 when the liquid has been substantially completely expelled as the piston 14 reaches the position shown adjacent the tank end 20. It is to be noted that in both forms of the invention, the rolling diaphragm expells the liquid contained with the volume of the fully collapsed bellows. A further advantage is flexibility of design in that the bellows may be fully extended or fully collapsed at the start of the liquid expulsion cycle.

It will now be apparent that the present invention eliminates the problems of cylinder buckling, incomplete liquid displacement, and material compatibility between tankage materials and the contained liquids (propellants) to permit a wide selection of materials having optimum tankage constructability characteristics.

An important advantage of the combined rolling diaphragm-bellows expulsion apparatus is that by using the axial flexibility of the bellows, the volume within the positive expulsion apparatus will always be full of liquid regardless of temperature changes or tankage positioning to thereby eliminate ullage variation and non-uniform impact forces at the start of liquid expulsion due to unsymmetrical liquid levels within the system.

It is to be understood that the forms of the invention there within shown and described are to be taken as preferred examples of the same and that various

changes in the shape, size and arrangement of parts may be resorted to without departure from the spirit of the invention or the scope of the subjoined claims.

What is claimed is:

1. The combination with a liquid expulsion tank having a discharge outlet and a piston movable by a pressurizing medium from one inner end of the tank to the other to expel the liquid therefrom; of a cylindrical diaphragm and bellows hermetically sealed together at one end and respectively to the piston and to said tank at their other ends to isolate the pressurizing medium from the liquid, said diaphragm being rollable backwardly within itself and through said bellows by the piston upon liquid expelling movement thereof.
2. The combination recited in claim 1 wherein the piston is formed integrally with said other end of said diaphragm.
3. The combination recited in claim 1 wherein said bellows is sealed to the tank only about the discharge outlet to isolate the liquid from the walls of the tank.
4. The combination recited in claim 1 wherein a tank liner is sealed to the tank and to said other end of said bellows and extends to and is sealed to a spaced point of the tank about the discharge outlet to isolate the liquid from the walls of the tank.
5. The combination recited in claim 1 wherein said bellows is in extended position at the start of the expulsion movement of the piston.
6. The combination recited in claim 1 wherein said bellows is in collapsed position at the start of the expulsion movement of the piston.

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