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ULLAGE CONTROL

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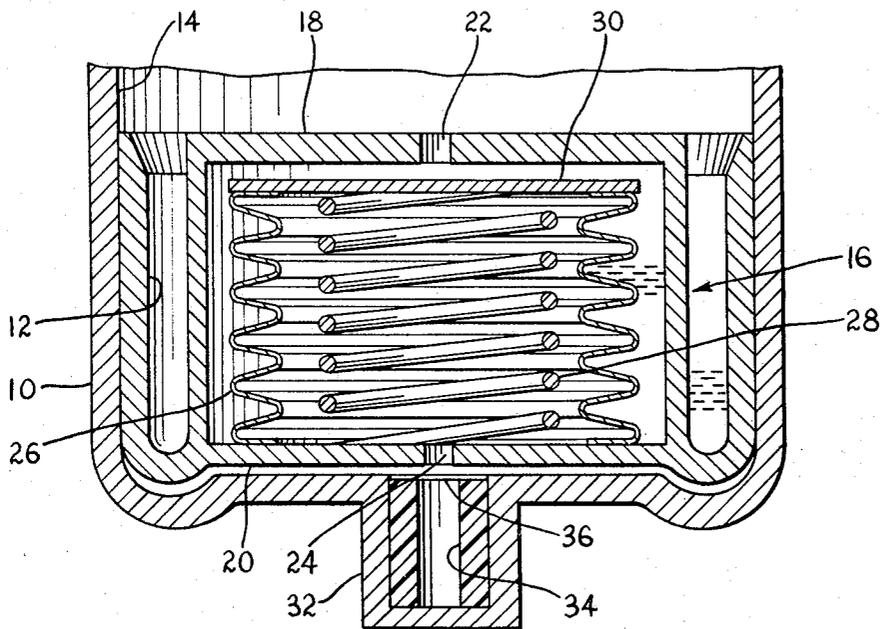


Fig. 1

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ABSTRACT OF THE DISCLOSURE

Ullage in a tank is eliminated by means of a device having a bellows that expands or contracts to compensate for change in liquid volume. The bellows is mounted inside a housing which is movably mounted in the tank on a rolling diaphragm. Liquid is expelled from the tank when pressurizing gases from a gas generator move the housing and rolling diaphragm.

This invention relates to fuel tanks and more particularly to means for ullage control.

The space between the surface of a liquid contained in a tank and the walls of the tank is referred to as ullage. When the ullage is large, sloshing of the liquid can occur, which in some instances, such as in the flight of rockets, is undesirable. Further, when pressurized gas is utilized for expulsion of the liquid, increases the time required to attain a predetermined operational liquid flow rate. If a large pressurizing gas flow is used to reduce flow rate under high ullage conditions, the pressurizing gas flow will be too high for low ullage conditions. In the art, absence of ullage is referred to as "zero ullage." The present invention provides zero ullage by the action of a bellows mounted on a diaphragm which rolls to expel the liquid.

Accordingly, it is an object of this invention to provide zero ullage in a tank containing liquid.

It is another object of this invention to provide a means by which liquid can be rapidly expelled from a tank over a wide range of operating temperatures.

The preferred embodiment of the invention will be described with reference to the accompanying drawing showing a central sectional view of the embodiment.

As illustrated in the drawing, a liquid (for example, a liquid fuel or oxidizer) is contained in tank 10. One end of a rolling diaphragm 12 is attached to the wall 14 of the tank, and the other end of the diaphragm is attached to a tubular housing 16, which is provided with a first end 18 and a second end 20 each having an aperture 22, 24 therein. A bellows 26 is disposed inside housing 16, and inside this bellows is a spring 28 which is under compression, thereby biasing the closed end 30 of bellows 26 toward first end 18 of housing 16. A gas generator 32 is centered at the bottom of tank 10. Although the burning charge 34 in the gas generator is illustrated as being a resin or plastic, other means for obtaining pressurizing gases could be employed.

During the storage of the liquid, its density and vapor pressure change with change in temperature, which tends to affect tank ullage. However, by selection of a spring 28 having a suitable spring constant, bellows 26 expands or contracts with changes of the liquid volume, whereby the volume defined by the interior surface of housing 16 and the exterior surface of bellows 26 is increased or de-

creased equally with the change in liquid volume, maintaining zero ullage in tank 10. When the liquid is to be expelled from the tank, gas generator 32 is fired by means not shown. Hot gases are generated by the burning of burning charge 34, rupturing a disc 36 and exerting pressure against housing 16. Diaphragm 12 rolls over itself as housing 16 moves along the tank. As liquid is expelled from tank 10, pressurizing gas from gas generator 32 enters bellows 26 through orifice 24 in second end 20 of housing 16. The pressurizing gas inside bellows 26 is at a higher pressure than the pressure of the liquid contained between the exterior of bellows 26 and the interior of housing 16, because a differential pressure is necessary to cause rolling of expulsion diaphragm 12. The differential pressure across bellows 26 therefore forces liquid through orifice 22 in first end 18 into tank 10.

Although a specific embodiment of the invention has been described and illustrated in detail, it is to be understood that various changes and modifications may be made there without departing from the scope of the appended claims.

What is claimed is:

1. An ullage control apparatus comprising:
 - a tank for holding liquid;
 - a tubular housing disposed in said tank and formed with first and second ends each having an aperture therein;
 - a bellows disposed inside said housing with one end thereof fixed to said first end of said housing so that the aperture in said first end communicates with the interior of said bellows, the other end of said bellows being closed and free to move to vary the volume defined by the interior surface of said housing and the exterior surface of said bellows;
 - spring means connected to said housing and said bellows for biasing the closed end of said bellows toward said second end of said housing;
 - seal means sealingly engaging said housing and the interior surface of said tank and allowing said housing to move relative to said tank; and
 - pressurizing means for moving said housing to thereby expel liquid from said tank.

2. An ullage control as defined in claim 1 wherein said seal means comprises a tubular rolling diaphragm bonded at one end to the interior surface rolling diaphragm bonded at one end to the interior surface of said tank and at its other end to said housing circumjacent said first end thereof.

3. An ullage control as defined in claim 1 wherein said pressurizing means comprises a gas generator.

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