

July 18, 1961

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2,992,622

TANK STABILIZER FOR SHIPS

Filed Dec. 20, 1957

2 Sheets-Sheet 1

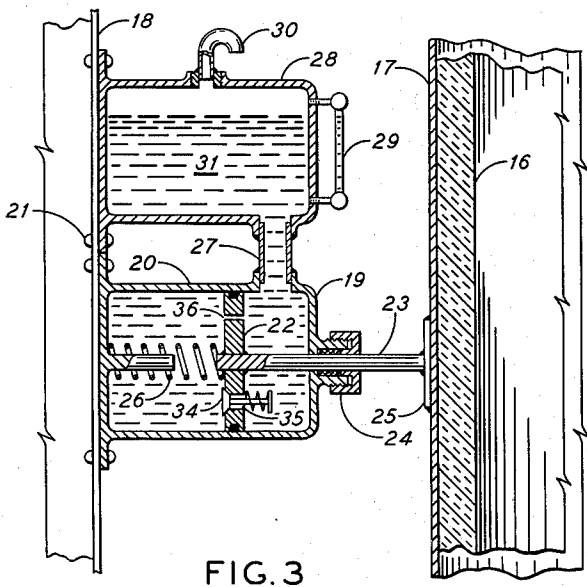
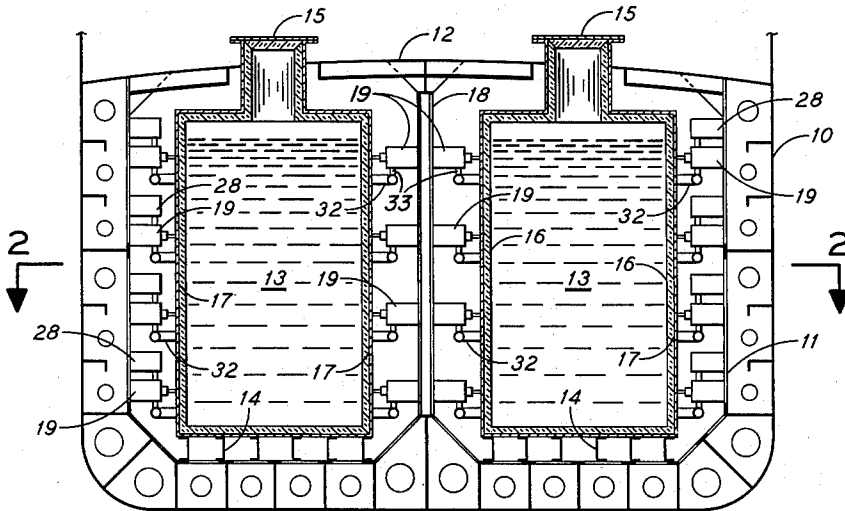
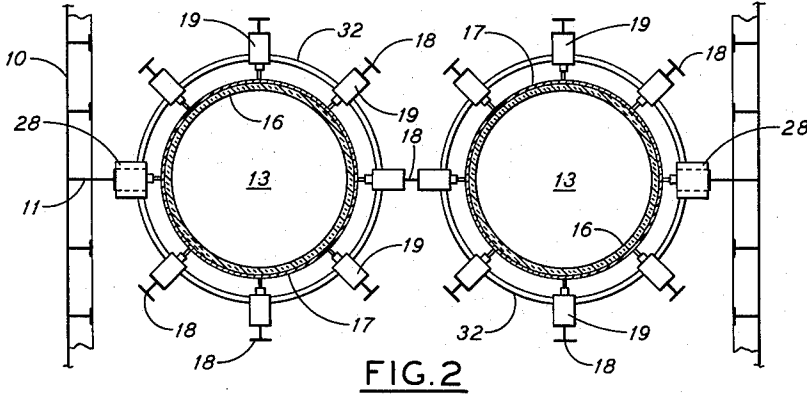


FIG. 1

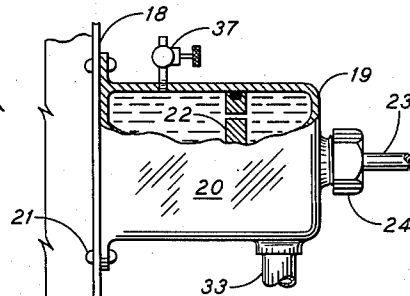


FIG. 4

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2 Sheets-Sheet 2

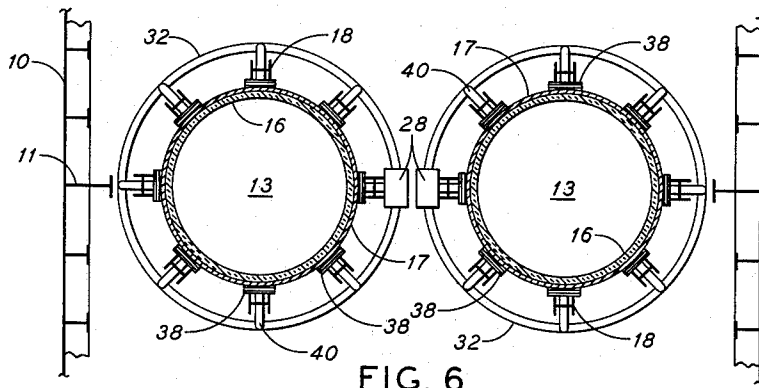


FIG. 6

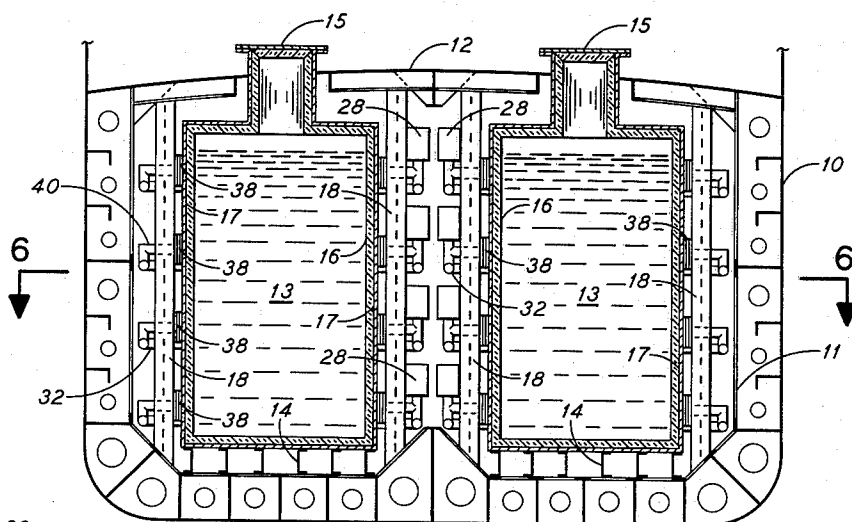


FIG. 5

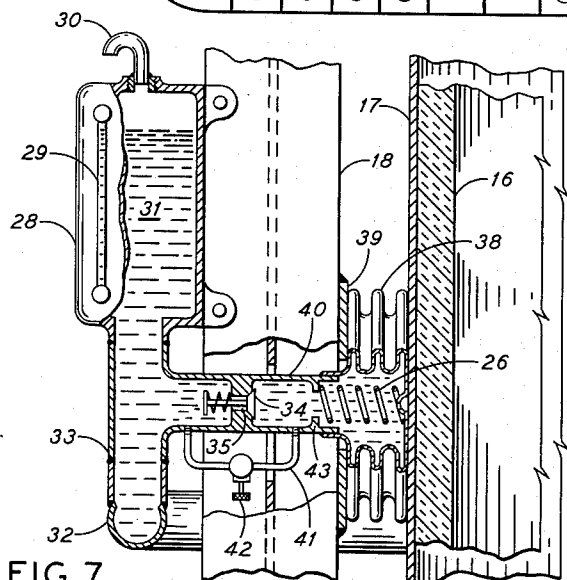


FIG. 7

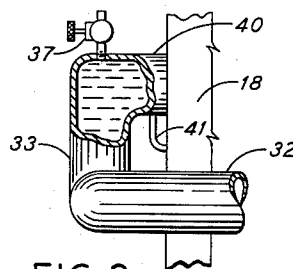


FIG. 8

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TANK STABILIZER FOR SHIPS

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Filed Dec. 20, 1957, Ser. No. 704,180

10 Claims. (Cl. 114-74)

This invention relates to the storage of volatile liquids in insulated metal tanks supported within a rigid structure, which may be a ship, and particularly refers to means for stabilizing the tanks against undesired movements resulting from rolling or pitching of the ship, while at the same time avoiding restraining forces against changes in dimensions due to changes in temperature of the tank relative to the ship's structure.

Heretofore, such tanks have been at atmospheric temperature and there has been no appreciable expansion or contraction of the tanks laterally. If an empty tank is filled with liquefied petroleum gases, for example, methane, ethane, ethylene, propane, propylene, and butane, at temperatures substantially below atmospheric, the tank shell will contract below its usual dimensions, and will be loose within its supports. Metallic restraints are not practicable because of stresses set up by rigid attachments, and because of conduction of heat whereby localized portions of the ship's structure may be cooled to undesirable or dangerous levels. It has been proposed to surround the tanks with an outer shell containing a water or liquid bath whose level is maintained at such a point that the inner tank will float and is free to move as a unit laterally through a limited extent, guided by radial tracks. All these, however, are not applicable to the configuration and sizes of tanks that are most economical in this service.

Small tanks may be suitably supported in this manner, but larger ones, for example, 20 to 40 feet or more in lateral dimensions, involve such forces and such magnitude of motion that either the shell or the enclosing structure would be distorted and possibly damaged if conventional methods were used.

This invention comprehends broadly the provision of a rigid framing within the ship, or made a part of its structure, and means surrounding the vertical wall of the tank at various levels adapted to exert controlled radial forces between the framing and portions of the tank wall. In this example, hydraulic means are provided in the form of expansible chambers supplied from liquid reservoirs, with means for controlling the flow of a suitable liquid between the reservoir and each chamber to accommodate expansions and contraction of the tank wall, as well as to resist generally horizontal forces set up during rolling or pitching of the ship.

It is an object of this invention to provide stabilizing means for a plurality of tanks in a ship's structure, these tanks being either cylindrical, or more desirably, rectangular in cross-section, so that they may conform to major divisions of a ship's hull.

Another object is to provide means for permitting limited and controlled relative movement between the tank wall and the ship's frame to limit stresses which would otherwise occur in both structures.

Another object is to provide for means that will control lateral forces acting against a ship's tank without interfering with substantial changes in the dimensions of the tank, and particularly in the horizontal directions, due to temperature changes.

These and other objects and advantages will be further apparent from the following specification, which illustrates preferred and alternative embodiments of the invention, taken in connection with the attached drawings, which form a part of this specification.

In the drawings:

FIGURE 1 is a vertical sectional view of a pair of tanks mounted in a ship, and illustrates vertically spaced rows of one embodiment of expansible chambers suitable for practicing this invention.

FIGURE 2 is a horizontal sectional view on line 2-2 of FIGURE 1 showing the circumferential spacing of the expansible chambers about the tanks.

FIGURE 3 is a detailed vertical sectional view of an individual chamber of the type of FIGURE 1, but showing an individual reservoir for the liquid supply to the chamber.

FIGURE 4 is a detailed vertical sectional view illustrating a chamber similar to that of FIGURE 3, but not provided with an individual reservoir.

FIGURE 5 is a vertical sectional view of a pair of tanks mounted in a ship, and illustrates vertically spaced rows of another embodiment of expansible chambers suitable for practicing this invention.

FIGURE 6 is a horizontal sectional view on line 6-6 of FIGURE 5 showing the circumferential spacing of the expansible chambers about the tanks.

FIGURE 7 is a detailed vertical sectional view of an alternate form of individual chamber of the type of FIGURE 5, showing a reservoir for the liquid supply to the chamber.

FIGURE 8 is a detailed vertical sectional view illustrating a chamber similar to that of FIGURE 7, but not provided with an individual reservoir.

Referring to the drawings, and particularly to FIGURE 1, reference numeral 10 illustrates generally the hull of a ship provided with frames 11 and a conventional deck 12. A pair of tanks 13 are supported on channel members 14 and are provided with an upward extension 15 projecting through deck 12. For convenience of illustration, these are indicated to be cylindrical, but it is contemplated that they may be of any desired configuration, such as rectangular, to make more efficient use of the spaces within the ship's hull that are dictated by its general design. The tanks 13 may be on the order of 40 to 80 feet wide by 60 feet long and a depth of 40 to 50 feet. The usual tank filling and emptying piping connections, pressure relief valves, and the like are not material to this invention and are not illustrated herein.

Tanks 13 are intended to contain liquefied methane, ethane, butane, propane, or mixtures of these, generally designated "L.P.G.," at substantially atmospheric pressure and at boiling point temperatures corresponding to their physical properties. They are heavily insulated as shown at 16. In this example, for convenience of illustration, the insulation is internal. Generally speaking, for many reasons, external insulation is preferable, as will be apparent to those skilled in this art. As the change in temperature of the tank shell 13 may amount to several hundred degrees, the metal walls 17 of tanks 13 will undergo considerable expansion and contraction when the tanks are filled or emptied.

To stabilize the tanks laterally, and thus restrain them securely within hull 10 without structural deformation or stress concentrations, there is provided, in this example, a group of vertical structural members 18 (FIGURE 2) suitably secured at their lower and upper ends to the hull and deck framing. Alternatively, the normal ship's framing may be used for this structure. Within the structure thus formed are vertically spaced rows of circumferentially spaced expansible chambers generally designated 19, which are resiliently biased to exert a controlled force between a limited portion of the shell 17 of each tank and the vertical structural members 18. The term "expansible chamber" is used herein in its generic sense, as will be illustrated in the several examples and pointed out in more detail below.

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Referring now to FIGURE 3, there is illustrated one form of an expansible chamber 19 which is adapted to exert a controlled radial force between a portion of the shell of tank 13 and a vertical structural member 18 secured to the framing or directly to the ship's hull 10. Chamber 19, in this example, consists of a horizontal hydraulic cylinder generally designated 20 secured as at 21 to a flange of member 18. A sealed piston 22 is slidably mounted in cylinder 20 and is provided with a piston rod 23 extending through a stuffing box 24. The outer end of rod 23 is secured to shell 17 as at 25. In this example, a rigid connection is shown, but if excessive vertical expansion of shell 17 is contemplated, a hinged or slidable connection could be employed. Inside of cylinder 20 and adapted to urge piston 22 and rod 23 toward shell 17 is a biasing spring 26. Optionally, spring 26 could be positioned outside of the cylinder between 17 and 19.

Above cylinder 20 and communicating therewith through a conduit 27 is a liquid reservoir 28 desirably provided with a gauge glass 29 and a vent 30. This maintains chamber 19 full of a hydraulic liquid 31, desirably chosen for its viscosity-temperature characteristics to be substantially uniformly viscous throughout the temperature range expected for the space in hull 10 in which chamber 19 is mounted.

Under some circumstances it may be desired to provide each of chambers 19 as indicated in FIG. 3 with its individual or separate hydraulic liquid reservoir 28. Under other conditions it may be desired to connect together a single liquid supply reservoir, such as 28 of FIG. 3, to all or part of a given horizontal row of chambers 19, as in FIGS. 1 and 2, by means such as header 32, connected thereto by conduits 33. In this example, this conduit is illustrated as being connectible to the lower part of cylinder 20 on the right, or inboard side of piston 22, so that it communicates freely with that space and with the interior of liquid reservoir 28. Thus, one liquid reservoir can be used to maintain any desired number or the entire row of chambers 19 filled with liquid 31.

Piston 22 is provided with a spring-restrained check valve 34 in a passage 35 leading from one side of the piston to the other. Additionally, a restricted orifice or passage 36 is provided in the piston body to permit a limited rate of flow of liquid from one side to the other.

In operation, and referring to FIGURES 1 and 3, when the tank 17 is filled with L.P.G. 13 it becomes cold and contracts, so that tank wall 17 tends to move away from member 18 and leave a gap. If this were permitted to occur, it would deprive the tank wall 17 of lateral support when movement of the ship develops horizontal inertia forces from the tank contents. The combined action of the bias spring 26 and the hydrostatic head of the liquid 31 causes piston 22 to move toward wall 17 and maintain a small predetermined force against it. If desired, the hydraulic fluid reservoir 28 of FIGURE 7 may be placed at such height above chamber 19 to impose all the force desired, so that spring 26 may be omitted.

The action of check valve 34 in passage 35 will permit substantially unrestricted flow of hydraulic liquid for this purpose. A surge of the tank contents to the left, as would be caused by the ship's rolling in opposite direction, will urge piston 22 to the left, thus closing the check valve 34. Thereafter, the restricted orifice or passage 36 will permit only a slow rate of flow of hydraulic liquid from the left to the right side of chamber 20, so that piston 22 is restrained and offers substantial opposition to motion caused by such inertia forces. Obviously, those expansion chambers 19 on the right or opposite side of tank 17 from the left-hand units just described (FIGURE 1) will be undergoing the reverse of the action just described.

When the opposite action occurs, that is, when contraction of tank 13 or ship motion tends to move wall

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17 away from member 18, piston rod 23 will urge the piston to the right, whereupon valve 34 will open and will permit relatively rapid flow of liquid through passage 35 from the right side to the left side of piston 22 within cylinder 20. In this example, the two flow control means, passage 36, and valved passage 34, 35 are in the piston body. If desired, an external bypass or valved conduit may connect the left and right ends of cylinder 20, as will be illustrated and described below.

Thus, there has been provided a controlled stabilizing action by each of expansible chambers 19 upon either expansion or contraction of a desired portion of tank shell 17 or upon sudden forces due to ship movement which would tend to move the tank relatively to the ship's hull. As these chambers are spaced around the periphery of the tank (FIGURE 2), forces acting in any substantially horizontal direction will be accommodated.

When tank 17 is emptied and warms up again, it will expand to its original dimensions. This will require a considerable length of time, however, due to the insulation and to the mass of the tank involved, so that for this slow rate of expansion, the required slow piston travel in cylinder 20 can be handled by the slow displacement of hydraulic liquid through the restricted orifice 36, which offers low resistance to low flow rates.

In order to prevent localized excessive forces being applied by the control means to tank shell 17, the resisting forces may be divided into vertical zones, each with a reservoir, rather than providing a single reservoir at a high elevation which would cause an increasingly greater force against the shell with increasing height of the hydrostatic liquid column. Alternatively, the lower expansible chambers 19 could be progressively smaller in diameter and connected to a single reservoir.

Referring now to FIGURE 4, there is illustrated a fragmental portion of the arrangement of FIGURE 3, in which the cylinder 20 is connected by conduit 33 to the common liquid supply header 32. This interconnects those chambers in a horizontal row which do not communicate directly with an individual reservoir 28. In this case, it is desirable to provide a gas bleeder valve 37 for each cylinder 20, so that the system may be maintained full of liquid 31 at all times.

Referring now to FIGURES 5-8, inclusive, there is illustrated an alternative arrangement of expansible chambers which include all of the essential features of the arrangement just described, but utilizing a flexible wall chamber 38, which may be a so-called "Sylphon" metal bellows, as shown, or a plastic or resilient bag, adapted to withstand internal pressure while remaining flexible to resist an externally applied force or load. FIGURE 5 illustrates diagrammatically the vertical rows of such chambers surrounding tanks 13 and adapted to exert the restraining forces to accommodate motion of the tank shell 17 inwardly and outwardly due to temperature changes, and also motion of the entire tank due to rolling or pitching of the ship. FIGURE 6 is a view on line 6-6 of FIGURE 5, illustrating the circumferential spacing of these chambers about the tank shell 17.

Referring now to FIGURE 7, it will be noted that flexible walled chamber 38, which may be termed an expansible chamber, is supported by a plate 39 secured to the vertical support member 18, so that it presses against a portion of tank wall 17, as shown, or, if the tank is externally insulated, against that body. A conduit 40 leads from flexible walled chamber 38 to a liquid reservoir 28 having a gauge glass 29 and a vent 30, as previously described. This is adapted to store the hydraulic liquid 31, which is controllably admitted to the interior of chamber 38 through conduit 40 by check valve 34 and an external bypass 41 provided with an adjusting valve 42, in the manner previously described for valve 34 and orifice 36 in the arrangement of FIGURE 3. Spring 26 and the hydrostatic head of liquid 31 exert the desired radial force between an abutment 43 in conduit 40 and the inner end

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face of chamber 38 in the same manner as is done by spring 26 and liquid 31 in FIGURE 3. As already described for FIGURE 3, the liquid hydrostatic head alone may be chosen to be sufficient for this purpose, so that spring 26 and abutment 43 may be omitted. Similarly, header 32 may be used to convey hydraulic liquid 31 to each of those chambers 38 which are not provided with an individual reservoir 28. The last-named chambers may be provided with gas venting or bleeder valves 37 (FIGURE 8) in the manner previously described for FIGURE 4.

In conclusion, it will be appreciated that there has been provided an improved means for stabilizing a vertical storage tank, particularly one used for liquefied petroleum gas in a ship's structure, so that expansion and contraction of the shell of the tank due to temperature changes, as well as forces exerted against the tank wall by motion of the ship, will be accommodated without lost motion and with a minimum of distortion and damage to either the tank or the ship's structure.

Although a limited number of specific examples and alternatives have been described and illustrated, it is apparent that numerous changes could be made without departing from the essential nature of the invention. Accordingly, all such changes and modifications that come within the scope of the appended claims are intended to be embraced thereby.

I claim:

1. In combination with a storage tank for L.P.G. service in a ship structure having a rigid framing substantially surrounding a vertical wall of said tank and spaced therefrom, the bottom of said tank being secured to and supported by said structure, means connecting said framing and a portion of said tank wall comprising a plurality of peripherally spaced liquid-filled expansible chambers resiliently biased to exert only horizontal forces between said framing and said wall portion, at least one liquid reservoir open to the atmosphere, conduit means connecting said reservoir to said chambers to exert a constant predetermined hydrostatic head thereon, and means responsive to changes in the liquid volume of said expansible chambers for controlling the flow of liquid between said chambers and said reservoir to modify said forces during motion of said tank wall from expansion and contraction due to temperature change, and to motion of said ship.

2. A combination according to claim 1, in which each of said chambers is provided with a separate liquid reservoir.

3. A combination according to claim 1, in which a plurality of groups of said peripherally spaced chambers are vertically spaced about said tank wall.

4. A combination according to claim 3, in which at least a part of the chambers in each of said groups in a given horizontal row are interconnected by a conduit and are supplied from a single liquid reservoir.

5. A combination according to claim 1, in which said flow control means comprises a valve in said conduit

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means biased to permit rapid flow of liquid into those chambers which tend to be expanded solely due to horizontal forces exerted between said tank and said framing.

6. A combination according to claim 5, in which said flow control means comprises bypass means in addition to the valve in said conduit to restrict flow of liquid into those chambers which tend to be contracted due to forces exerted between said tank and said framing.

7. A combination according to claim 1, in which said expansible chamber comprises a flexible wall container and said connecting means includes mounting means on said framing for supporting said container between said tank wall and said framing.

8. A combination according to claim 1, in which said expansible chamber comprises a rigid container and a piston moveable therein, said connecting means includes means directly connecting said piston and said container to said tank wall and said framing, and said means for controlling liquid flow includes valve means and orifice means to permit flow from one side to the other side of said piston upon relative horizontal movement between said tank wall and said rigid framing.

9. Means for stabilizing a vertical tank within and spaced from a rigid enclosing structure secured in a ship's hull against horizontal forces exerted by said tank on said hull, comprising a liquid-filled expansible chamber interposed between a side wall of said tank and said structure adapted to exert a radial force between a portion of said structure and a portion of the wall of said tank, reservoir means for maintaining said chamber filled with liquid under a predetermined constant hydrostatic head, and means responsive to changes in volume of said liquid-filled expansible chamber for controlling the flow of liquid between said reservoir and said chamber, to reduce the tendency of said tank to move horizontally within said space between said structure and said tank.

10. Means according to claim 9, in which said flow control means comprises valve means biased to allow rapid flow of liquid into said chamber upon expansion in volume of said chamber when said tank wall portion tends to recede from said structure portion and orifice means to restrict flow in the opposite direction upon contraction in volume of said chamber when said tank wall portion tends to approach said structure portion.

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