United States Patent

Fernandes et al.

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[54] **PHASE SEPARATOR**

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[51] **Int. Cl.**.....**B65b 31/04,** B67c 3/02

[58] **Field of Search**.....141/18, 29, 285, 286, 291, 141/292, 293, 294, 295, 296, 301, 302, 392, 374, 94, 95, 59, 37–53, 54–58; 138/37–46, 111–117

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[57] **ABSTRACT**

A body providing an interior helical flow path for separation of fluid in the vapor phase from a flowing liquid stream. Separate passages lead from the flow path and from one end of the body and in one of these is venturi means exerting an eduction influence on the other passage.

11 Claims, 2 Drawing Figures

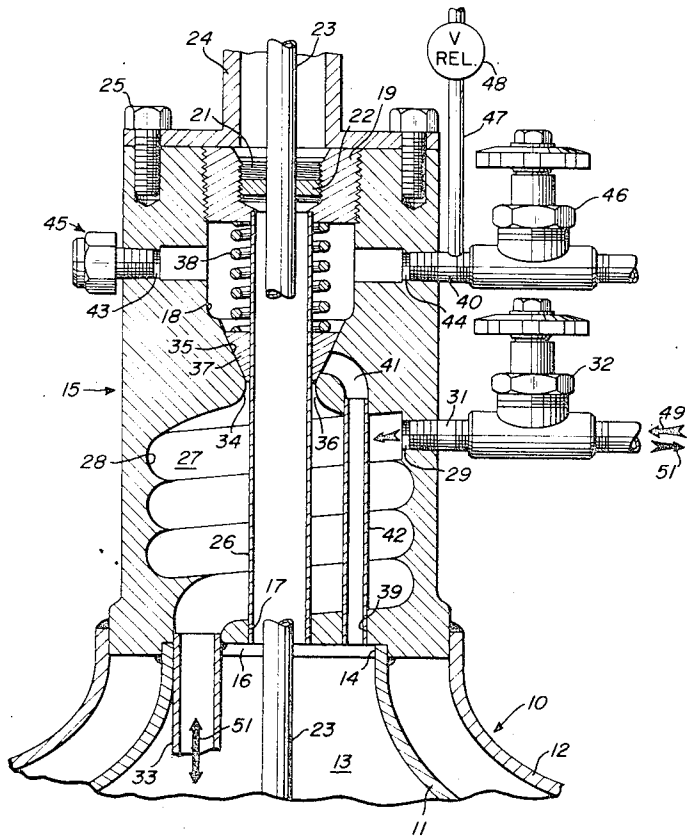


FIG-1

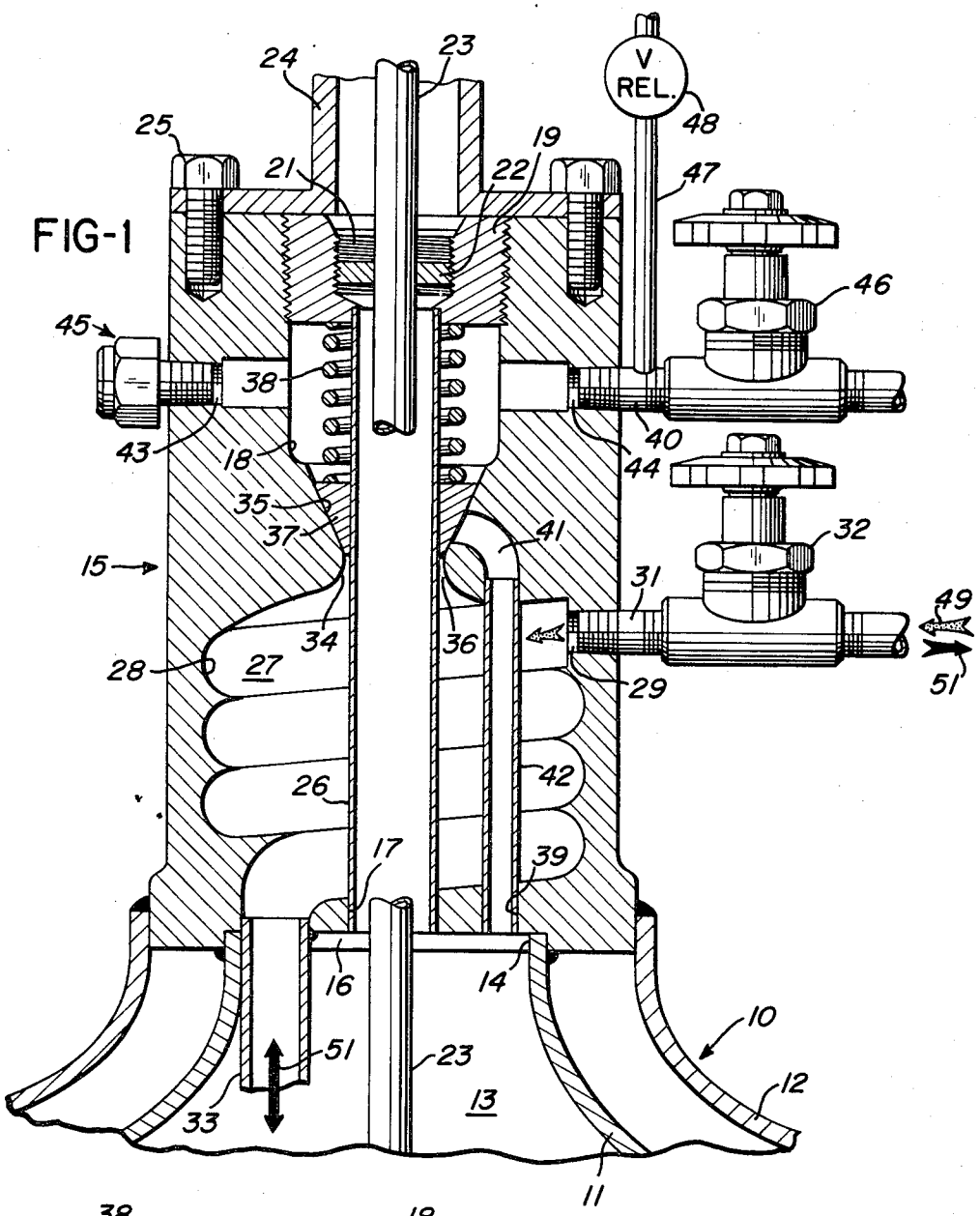
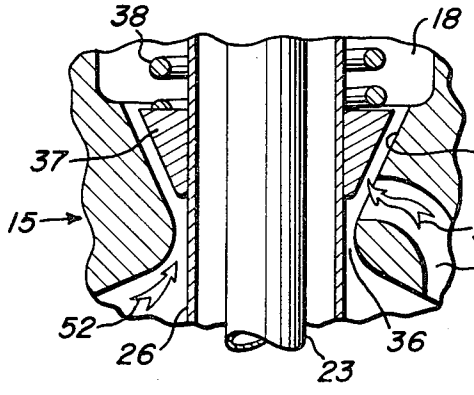


FIG-2



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BACKGROUND OF THE INVENTION

This invention relates to a device separating a two-phase fluid into liquid and gas components. Although not so limited, it has special reference to liquid containers and particularly to means allowing the rapid filling of such containers with a saturated liquid. In a specific embodiment, the invention deals with the problem of filling containers with cryogenic fluids, that is, with oxygen, liquid hydrogen or the like, rapidly and without excessive loss by vaporization. In the pertaining fluid handling art, cryogenic fluids are taken from bulk storage and transferred to double walled vessels known as dewars, by which they may expeditiously be transported to a place of use and selectively drawn upon as needed. The cryogenic fluid reaches the dewar in an essentially two-phase form, substantial amounts of vapor being liberated from the liquid due to warming and pressure decrease. A vapor outlet from the dewar provides for escape of gases after they have reached the dewar and after they have risen to the upper part thereof. This is a relatively slow process, however, so that filling of the dewar with a saturated liquid has heretofore been slow and has been accompanied by excessive vapor loss.

The instant invention has in view a combined inlet-outlet fitting constructed to promote phase separation before the cryogenic fluid reaches the dewar interior. The liquid entering the dewar accordingly flows at a higher mass flow rate. The filling time is reduced and the amount of vapor phase fluid lost to the vent outlet is reduced. In an optional feature of the invention, the separated vapor phase fluid escapes through means utilizing the flow thereof to evacuate the upper part of the dewar interior. Vapors released within the dewar are thereby with greater facility conducted to the vent outlet.

An object of the invention is to provide means of general utility removing gas from a flowing stream comprising liquid and gas.

Another object of the invention is to provide separator means allowing rapid filling of closed containers with saturated liquid.

A further object of the invention is to provide a device which can be installed on new or existing dewars and like vessels for a rapid filling thereof with minimum vapor loss.

Other objects and structural details of the invention will appear from the following description, when read in connection with the accompanying drawings, wherein:

FIG. 1 is a partly diagrammatic view of a device in accordance with the instant invention shown applied to a dewar for the handling of cryogenic fluids; and

FIG. 2 is a detail, fragmentary view showing a valve in the device of FIG. 1 in an open position.

Referring to the drawings, the invention is disclosed in a system handling cryogenic fluids. In such systems, a cryogenic fluid such as liquid oxygen or liquid nitrogen is taken from a place of bulk storage and transferred to a dewar 10 by which the cryogenic fluid is transported to a place of use and drawn upon as required. The dewar 10 is a double walled insulated container comprised of spaced apart inner and outer walls 11 and 12. Inner wall 11 defines the interior storage compartment

of the container, a space herein indicated at 13. A relatively small diameter mouth 14 at the upper end of the dewar provides an entrance to and exit from interior space 13.

The illustrative concept of the invention provides a body 15, an end of which seats on the reduced diameter upper end of the dewar 10 in a closing relation thereto. Thus, outer wall 12 receives the end of body 15 in an interfitting relation and is suitably secured thereto, as by welding. The inner wall 11 is received in a recess 16 in the end of body 15 and similarly is secured, as by welding, to the body. The space between the walls 11 and 12 accordingly is effectively closed. The mouth 14 communicates with space 16.

The body 15 has a through longitudinal bore 17. At what may be considered the upper end of the body, or that end remote from recess 16, a counterbore 18 is formed. A threaded bushing 19 is installed in to close the upper end of counterbore 18. An interiorly threaded portion 21 of the bushing 19 provides a place of mounting for a combination seal and bearing element 22. A rod 23 has a sliding bearing in element 22 and extends downwardly through the bore 17 of body 15 into container space 13. The rod 23 is a level indicator and is adapted selectively to be capable of relative vertical movement in the assembly comprising dewar 10 and body 15. A housing 24 is secured to the upper end of body 15 by bolts 25 and extends upward in a closed, surrounding relation to rod 23 in a manner which it is unnecessary here to consider. A tube 26 is mounted at its ends in the body 15 and in the bushing 19 and provides an enclosure for the rod 23.

A portion of the body 15 between its ends is constructed as an interior chamber 27. Integrally formed in the wall of the chamber 27 is a helical passageway 28. An upper end of passage 28 communicates with a lateral, through opening 29 in the side of the body wall. A lower end thereof is turned longitudinally downward in radially offset relation to the body axis and opens into recess 16. A pipe 31 is installed in opening 29 and provides a combined fill and draw off means. A valve 32 is interposed in pipe 31 and is manually adjustable to an open and to a closed position with respect to flow through the pipe. At the lower end of passage 28, a tube 33 has one end extending through recess 16 to be received in and communicate with passage 28. The tube 33 extends vertically downward into container space 13 and may advantageously project to a point near the bottom of such space.

The body chamber 27 is connected to counterbore 18 by a curving interior body surface 34 which expands as it extends toward counterbore 18 to define a conical surface 35. Curving surface 34 defines with the exterior of tube 26 a restricted flow passage 36. The surface 35 provides a seat for a valve 37 which surrounds tube 26 and in seating on surface 35 effectively closes passage 36. A compression spring 38 seats on the bushing 19 and urges valve 37 normally closed.

The body chamber 27 communicates at its lower end with the recess 16, and thereby with container space 13, through an opening 39. The upper part of the chamber 27 communicates with one end of a curving passage 41, the other end of which opens through conical surface 35. The described other end of passage 41 is closed in a seated position of valve 37 and opened in a

raised or open position of the valve. Opening 39 and passage 41 are connected by a tube 42.

The body 15 has circumferentially spaced apart radial openings 43 and 44 communicating at their inner ends with counterbore 18. Installed in to close opening 43 is a fitting 45 incorporating a rupture disc (not shown). A pipe 40 is screwed into opening 44 and extends to atmosphere or to a suitable place of vent. A manual valve 46 is interposed in pipe 45 and is alternatively adjustable to open and close such pipe to a flow of fluid therethrough. The counterbore 18 is further connected to vent or to the atmosphere by other, pressure responsive, means, and, for convenience of illustration, this has been shown diagrammatically as a line 47 incorporating a pressure relief valve 48 and communicating with pipe 40 in advance of valve 46.

The cryogenic fluid is in storage maintained under pressure and in a substantially saturated condition. In the transfer operation, from storage to a dewar, use is made of the inherently pressurized condition of the fluid or pumps are utilized. In either event, the fluid reaches the body 15 as a two-phase fluid comprising whole liquid and entrained gases or vapors. Pressure reduction produces a gas in the fluid. Also, warming of the fluid which is a necessary result of directing it through pipe lines and passages to the dewar, releases vapors.

The opening 29 has a non-radial disposition. It aligns tangentially of chamber 27 or more particularly of helical passage 28 therein. In entering passage 28, therefore, the two-phase fluid supplied through pipe 31 goes into a swirling movement producing results characteristic of a centrifugal separator. Heavy liquid particles go to and remain in the outside of passage 28 while lighter vapors and gases separate from the liquid and move toward the center of chamber 27 where they rise along the exterior of tube 26 to and through passage 36. A pressure difference across valve 37 is established, causing this valve to raise to an open position, substantially as shown in FIG. 2 of the drawings. An open flow passage accordingly is defined from chamber 27 through passage 36 into counterbore 28 and out passage 44 to and through vent pipe 40. The devaporized liquid continues in its path through passage 28 and discharges therefrom into tube 33 to be conducted thereby to container space 13, the tube 33 terminating as before indicated at any selected level within the container space. The unseating of valve 37 opens the passageway defined by opening 39, passage 41 and tube 42, which passageway communicates through the open mouth 14 of dewar wall 11 with the container space 13 in the upper part thereof. Accordingly, vapors released within space 33 and rising to the top thereof are free to join the centrifugally separated gases and exit through vent pipe 45. The arrangement is such that the cryogenic fluid enters tube 33 in a saturated condition and flows at a higher mass flow rate than would be the case if it were in the form of the two-phase mixture in which it reaches body 15. Further, released gases within the container space 13 are expeditiously removed by way of tube 42 and communicating passages so that there is little resistance to a quick and easy filling of dewar interior space 13. In this latter connection, the curving surface 34 of body 15 which defines passage 36, and the divergently inclining surface 35 leading upwardly therefrom form a passageway having the characteristics of a venturi. The location of passage 41 is such that it and communicating spaces are subjected to an education influence as centrifugally separated vapors rise through the passage 36 and expand into the continuation thereof defined by conical surface 35. The education effect, exerted upon the upper part of container space 13 assists in the exhausting of this space of released vapors.

In a fluid transfer operation, manual vent valve 46 is opened and the manual fill-drawoff control valve 32 is open. The two-phase fluid, as represented by the stippled arrows 49 is free to flow through pipe 31 into helical passage 28. Saturated liquid, represented by solid arrows 51 reaches tube 33 and is directed thereby toward the bottom of container space 13. Released vapors, as represented by open arrows 52 flow to vent pipe 40 by way of venturi passage 36 and by way of tube 42. When filling is complete, both valve 32 and manual vent valve 46 are closed. Pressure in the dewar, which is function of the continuing attempted expansion of the cryogenic fluid, equalizes in chamber 27 and in counterbore 18 whereupon valve 37 closes. When it is desired to draw off liquid from the dewar valve 32 is opened. Internal pressure forces liquid from the space 13 upward through tube 33 and through chamber 27 to opening 29 and pipe 31 which at this time assume the character of outlets for the discharging liquid.

If, while the liquid is stored in dewar 10, internal pressures rise to an undesirable height, valve 48 relieves to vent excess pressure. The rupture disc in fitting 45 serves a similar function in the event valve 48 is inoperative or unable to vent pressure at a desired rate.

Used with unpressurized liquid containers, the device of the invention would omit valve 37 and may omit vent valve 46. Released gases would flow directly to the atmosphere or place of venting.

It is evident, moreover, that the device provides a phase separator of general utility, structural details of which may vary substantially within the broad concept characterizing the invention.

The invention allows rapid filling of closed containers with saturated liquid. It is of maximum advantage when the source fluid is composed of both liquid and gas phases. Its most apparent application is in the filing of dewars with cryogenic fluids. However it will function with other fluids, and can be used to extract liquid samples from a two phase stream of fluid. A device according to the invention will normally be used to fill vessels with liquid from a source which is at a pressure above ambient.

In the illustrative embodiment of the invention, it has been assumed that vapor rise through opening 36 is a primary flow while that discharging from space 13 through tube 42 is a secondary flow. Should conditions be such that the reverse is true, then the structure of body 15 may appropriately be revised for a reverse venturi effect. For example, level indicator 23 could be omitted or relocated, the upper end of tube 26 flared outward in the manner of surface 35, with radial openings at the base of such surface communicating with counterbore 18, and a plug valve biased to close flow through the tube past such radial openings. The vent connection would be beyond the plug valve. The

connection 39, 41, 42 would be omitted, with vapor flow out of the dewar being by way of tube 26. Venting of vapor released from fluid in helical path 28 would be by way of the described radial openings in tube 26, influenced by the primary flow thereby.

What is claimed is:

1. A device for separating vapor phase fluid from a flowing liquid, including a body providing a flow path for the liquid in which centrifugal forces are utilized for a release of vapor phase fluid with a directed escape thereof through a vapor phase flow passage to a vapor outlet, a separate vapor flow passage in said body leading to said outlet, and means utilizing vapor flow through one of said passages to induce flow in the other passage.

2. A device according to claim 1, wherein the first said flow passage includes venturi means and wherein said separate flow passage communicates with said first flow passage in position to be evacuated by flow through said venturi means.

3. A device according to claim 1, wherein said body provides a liquid inlet and an internal helical path terminating in a discharge opening at one end thereof, the first said flow passage forming venturi means centrally of said helical path through which vapor phase fluid released from liquid in said helical path escapes, said separate vapor flow passage opening through said one end of said body and leading to the first said flow passage at a location to have flow therethrough influenced by flow through said venturi means.

4. A device according to claim 3, wherein said helical flow path is formed in a first chamber in said body, a second chamber therein being longitudinally spaced from the first chamber and connected thereto by said venturi means, said vapor outlet communicating with said second chamber, and an opening in said body communicating with the first said chamber for admitting liquid to said helical path.

5. A device according to claim 4, characterized in that said device is useful on and in connection with a vessel, said discharge opening and the said separate flow passage communicating through said one end of said body with the vessel interior.

6. A device according to claim 5, characterized by a spring loaded valve normally seated in to close said venturi means and opening under released vapor pressure in said first chamber, said separate vapor flow passage extending to said venturi means in position to be closed by said valve when seated therein.

7. A device useful in the liquid filling of vessels to facilitate separation and removal of fluid in the vapor phase, including a body adapted to mount on to be a part of a vessel, said body providing a flow path for incoming fill liquid in which entrained vapors are inherently released and having an outlet through which such released vapor escapes prior to reaching said vessel, and means utilizing escaping vapor released in said flow path to induce vapor flow from the vessel interior.

8. A device according to claim 7, characterized by pressure responsive valve means intermediate said flow path and said vapor outlet restricting escape of released vapors.

9. A liquid container of rapid fill characteristics, including a container having a mouth through which it is filled and through which contained liquid is drawn off, a body installed in a closing relation to said mouth and having a liquid flow passage for fill and draw off, means in said passage way imparting a centrifugal effect to incoming liquid for a release of vapor phase fluids therefrom, and means in said body providing for escape therefrom of released vapor phase fluid prior to reaching said container.

10. A liquid container according to claim 9, characterized by a valve biased to restrict escape of vapor phase fluids for a pressurizing of the container interior.

11. A liquid container according to claim 9, characterized by a separate flow passage way intercommunicating said last named means and the vessel interior providing for the escape of vapor phase fluids released in the container.

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