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[54] **VERTICAL JET BREATHER VALVE**

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[51] **Int. Cl.**.....**F16k 17/194,** F16k 17/196

[58] **Field of Search**.....137/493.3, 493.4, 589; 251/122

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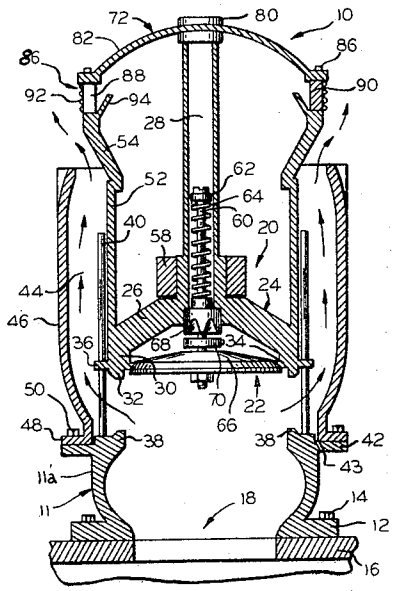
[57] **ABSTRACT**

A vertical jet breather valve capable of relieving sub-atmospheric and super-atmospheric pressures within a tank, and including a tank vapor-air mixing annular outlet opening for relieving super-atmospheric pressures and creating substantially constant velocity by self-adjusting the outlet opening proportioned to the tank vapor volume or filling rate.

7 Claims, 4 Drawing Figures



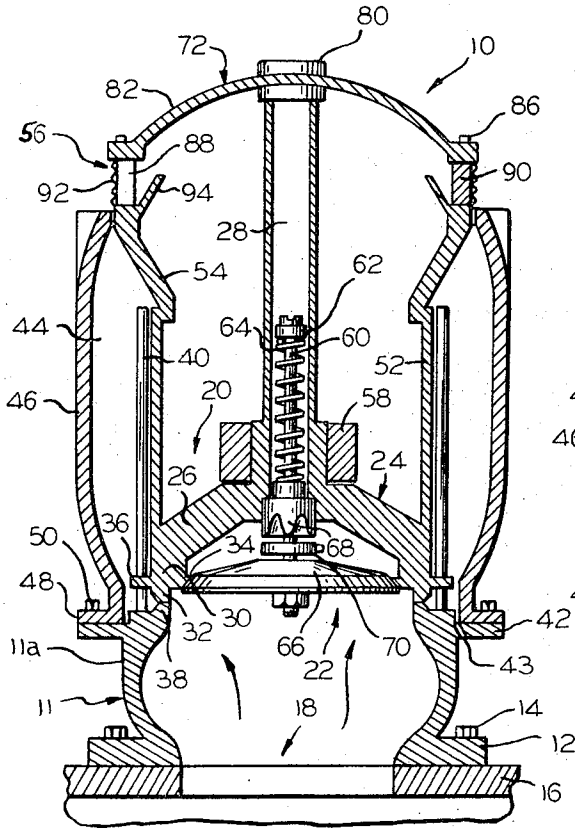


FIG.1

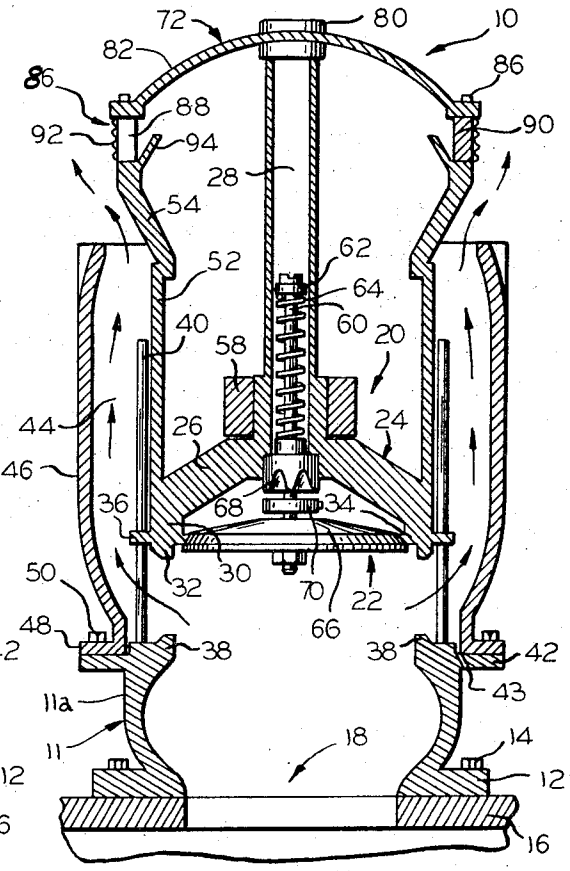


FIG.2

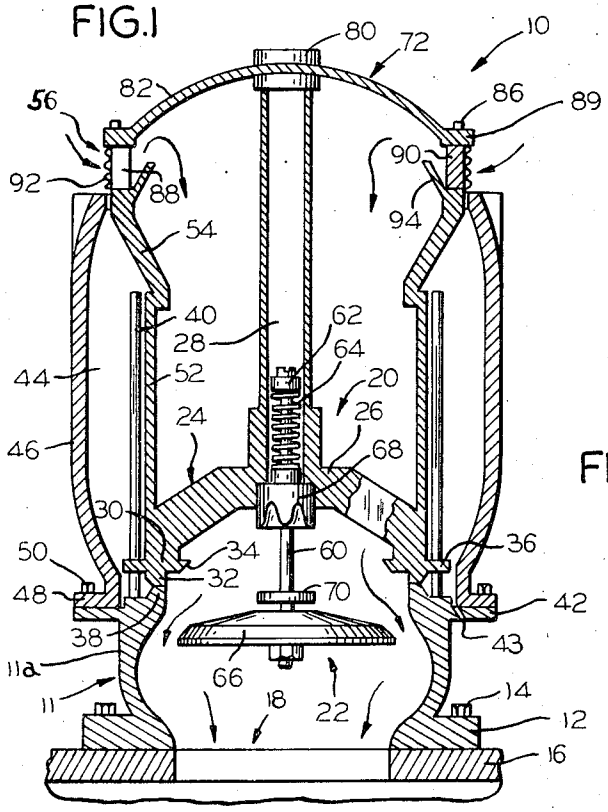


FIG.3

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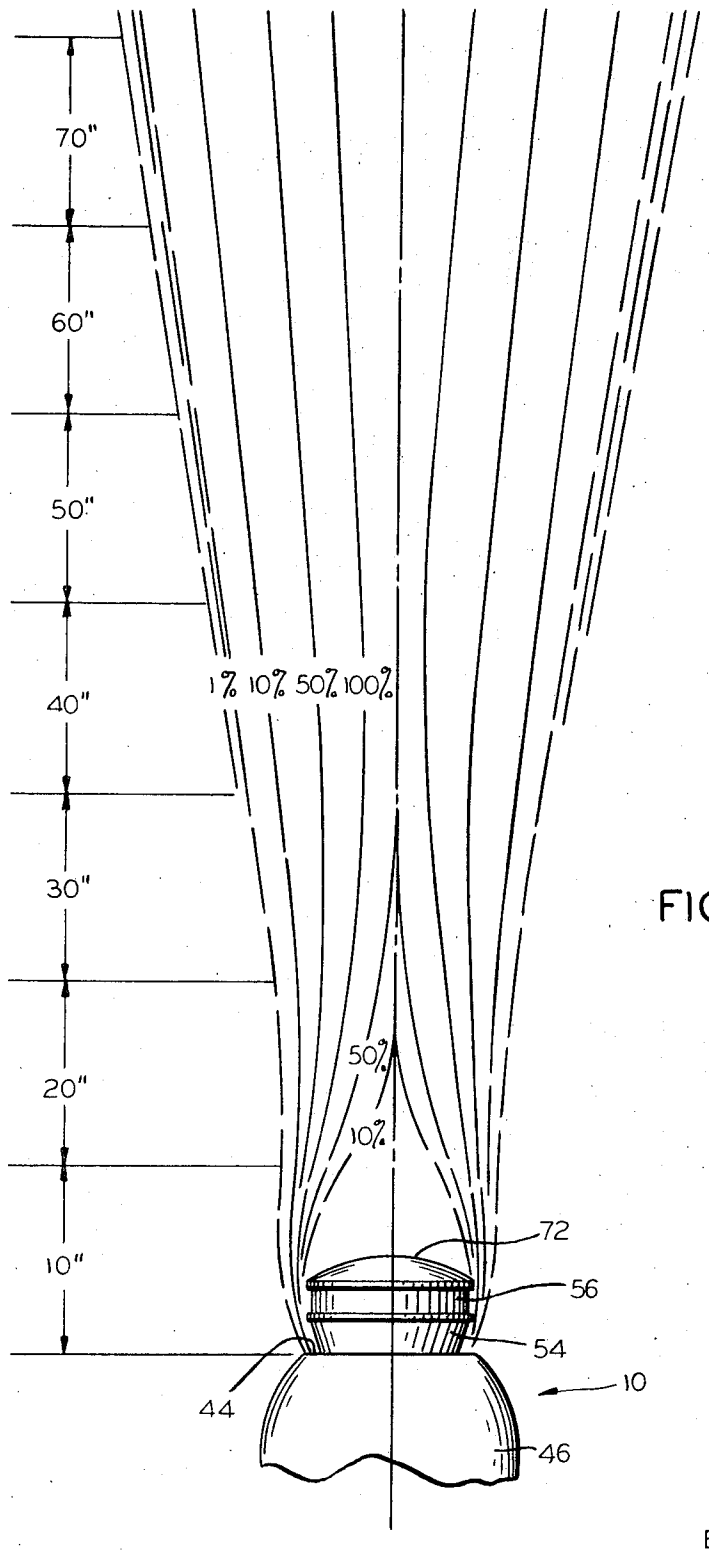

FIG. 4

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VERTICAL JET BREATHER VALVE

This invention relates in general to valves, and more particularly to a vertically mounted, relief valve for a tank on a marine vessel containing a flammable product, such as a petroleum product.

Relief valves are used to release some flammable vapor from a tank when the pressure in the tank becomes too great. The vapor is released in a vertical jet and is mixed with the air in the atmosphere. The outlet of these valves is constructed to cause the jet of vapor to mix rapidly with the air to be thinned until it can no longer be accidentally ignited. The problem is especially encountered while pumping product into the tank of a docked vessel. It is important that the vapor emitted be quickly mixed with the surrounding air to minimize fire hazards.

In a known relief valve, the pressure in the tank lifts a weighted valve element having a movable wall that includes a circular opening positioned around a stationary cone to form an annular outlet at the base of the cone. The vapor is released through the annular outlet between the valve element and the cone and is directed upwardly along the walls of the cone. A cover is provided to prevent water from flowing down the cone into the valve outlet during foul weather.

The valve of this invention permits air to enter the tank when pressure in the tank falls a predetermined amount below atmospheric pressure and permits vapor to leave the tank when pressure in the tank rises a predetermined amount above atmospheric pressure. It operates in any weather.

To control the flow of air into the tank, the valve includes a vacuum pallet that is held in a valve seat by a magnet and by a compression spring until the vacuum pressure in the tank reaches a predetermined limit, at which time the vacuum pulls the vacuum pallet free from the valve seat. Air enters the tank by flowing into the valve through horizontal inlets that are protected by a screen and baffle and then flows through the valve into the tank. The vacuum pallet is returned to the valve seat by the compression spring when the vacuum pressure in the tank decreases sufficiently.

To control the flow of vapor from the tank, the valve includes: (1) a vertically extending contoured outlet channel with an upper annular valve outlet at its upper end; (2) a lower annular valve outlet with a water drain aperture at its lower end that communicates with the contoured outlet channel in a substantially horizontal direction near its lower end above the drain aperture; and (3) a weighted pressure pallet which opens and closes the upper and lower annular valve outlets. When the pressure in the tank reaches a predetermined value, it lifts the weighted pressure pallet to open the lower and upper valve outlets a distance proportional to the vapor flow from the tank into the contoured outlet channel and from the contoured outlet channel to the atmosphere.

The contoured outlet channel directs the vapor from its upper annular outlet in a direction that is upward and radially outward from the vertical central axis of the outlet, with the highest velocity vapors at the center of the vertical axis of the outlet. The high velocity causes a rapid mixing of the vapor with air. The rapid mixing of the vapors with the air slows down the velocity of the vapors towards the outer edge of the jet stream. The escaping velocity at the outlet remains nearly constant because the tank pressure from the time the valve opens until the valve closes drops only ten to fifteen percent. Moisture that enters the upper outlet is drained through the aperture at the bottom of the contoured outlet channel and does not flow through the lower outlet into the tank so no cover is needed for the valve during foul weather.

It is therefore an object of the present invention to provide a new and improved all weather relief valve.

Another object of this invention is the provision of a valve that is capable of relieving pressure and partial vacuum within a tank caused either by an increase of the pressure in the tank above atmospheric pressure or the decrease of the pressure to below atmospheric pressure.

A further object of this invention is to provide a vertical jet valve which provides a high velocity stream resulting in rapid mixing of the vapor with air.

Still another object of the invention is the provision of a novel near constant-velocity emission relief valve.

Other objects, features and advantages of the invention will be apparent from the following detailed disclosure, taken in conjunction with the accompanying sheets of drawings, wherein like reference numerals refer to like parts, in which:

FIG. 1 is a diagrammatic view, partly in vertical section taken through the longitudinal axis of the valve of the invention mounted on a tank wall and illustrating the valve closed;

FIG. 2 is a view similar to FIG. 1, illustrating the valve open to pass vapor from the tank;

FIG. 3 is a view similar to FIG. 1, illustrating the valve open to pass air into the tank; and

FIG. 4 is a diagrammatic view of the profile of a fluid jet leaving the valve.

In FIGS. 1–3, a vertical jet marine breather valve **10** according to the invention is shown, having a base **11** with a substantially vertical tubular wall **11***a* and an outwardly extending base flange **12** bolted to a horizontal wall **16** of a tank by bolts **14** to form a fluid tight seal around a valve opening **18** and outlet in the tank wall **16** aligned therewith. The valve **10** includes a first pressure adjustable valve element **20** to permit fluid (primarily as a vapor) to leave the tank when the pressure in the tank is a predetermined value above atmospheric pressure and a second pressure adjustable valve element **22** to permit air to enter the tank when the vacuum pressure in the tank is a predetermined value below atmospheric pressure.

To control the flow of fluid from the tank, the first pressure adjustable valve element **20** includes a spider **24** having a plurality of legs **26** extending downwardly and outwardly from the base of a centrally located supporting cylinder **28** to an annular outer supporting ring **30**. The outer supporting ring **30** includes an annular flat-bottomed pressure pallet **32** extending below an inwardly extending annular flange **34** and an outwardly extending flange **36** having a plurality of circumferentially spaced apertures therethrough.

The top of the tubular wall **11***a* cooperates with the pressure pallet **32** and the apertured flange **36**, having for this purpose: (1) a radially inwardly located annular valve seat **38** against which the pressure pallet **32** seats to form a seal when the valve **10** prevents fluid from leaving the tank; (2) a horizontal central portion that

supports a plurality of vertically extending guide posts **40**, each of which passes through a different one of the apertures in the outwardly extending flange **36** to guide the valve element **20** as it is raised or lowered; and (3) a horizontal outwardly extending flange **42** having a plurality of outwardly extending drain openings through it, one of which is shown at **43**.

To guide fluid from the tank as it leaves the valve **10** and is released into the atmosphere, a contoured outlet channel **44** is provided having a tubular outer wall **46** extending upwardly from a flange **48** which is bolted to the flange **42** of the wall **11***a* with bolts **50**. A tubular inner wall of the contoured outlet channel **44** extends upwardly from the outer supporting ring **30** of the spider **24**, and has three sections, which are: (1) a lower vertical cylindrical section **52** extending upwardly from the outer supporting ring **30** and ending in an inwardly extending horizontal flange; (2) a hollow, inverted, frustum section **54** extending upwardly and outwardly from the inner portion of the flange at the end of the cylindrical section **52**; and (3) an upper vertical cylindrical section **56** extending upwardly from the end of the frustum section **54** and having a larger diameter than the lower cylindrical section **52**.

The outer and inner walls of the contoured outlet channel **44** are shaped so that, when the valve element **20** is in its lower or closed position, an inwardly turned end of the outer wall **46** is in near engagement with a solid lower portion of the upper cylindrical section **56** of the inner wall and, when the valve element **20** is in its upper or open position, the inwardly turned end of the outer wall **46** is spaced a substantial distance from the lower portion of the inverted frustum section **54** to permit the easy exit of fluid.

With this arrangement, the contoured outlet channel is substantially closed when the valve element **20** is in its lower position. When the valve element **20** is in its upper position, the contoured outlet channel provides a path for the flow of the fluid against the inverted frustum section **54** and the vertical cylindrical section **56** to achieve relatively fast mixing of the fluid with air as best shown in FIG. **4**. Moreover, the sloping walls of the inverted frustum section **54** cause the contoured outlet channel **44** to partly close as the pressure or the vapor volume in the tank decreases and lowers the valve element **20**. This enables the exit velocity of the fluid to remain high as the volumetric flow of fluid drops.

In the preferred embodiment, the ratio is a constant one to one ratio so that the exit velocity remains substantially constant while the vapor volume in the tank changes.

To adjust the pressure at which the pressure adjustable valve element **20** opens the valve to permit fluid to leave the tank through the contoured outlet channel **44**, a selected or a plurality of selected ring-shaped weights **58** (FIGS. **1** and **2**) are placed around the supporting cylinder **28** where they rest upon the spider **26** to bias the valve element **20** downwardly into the closed position.

To control the flow of air into the tank, a vacuum pallet **66** is provided in the second pressure adjustable valve element **22**. The vacuum pallet **66** is a generally flat disc mounted at its center to a valve stem **60** and having a top surface that slopes slightly downwardly from the stem **60** to a beveled edge that is seated on a complementally beveled valve seat on the annular flange **34** when the valve stem **60** is in its uppermost position whereby air is prevented from entering the tank. When the valve stem **60** is in a lower position so that the vacuum pallet **66** is spaced a distance below the valve seat on the flange **34**, air is permitted to flow downwardly around the sloping top surface of the vacuum pallet **66** and into the tank.

To mount the vacuum pallet **66** in the second pressure adjustable valve element **22**, one end of the valve stem **60** extends into the centrally located supporting cylinder **28** where it threadedly engages a nut for holding a spring **64** and spring retaining collar **62** about the stem **60** and the other end extends downwardly below the spider **24** where it threadedly engages a nut for holding the vacuum pallet **66** onto the stem **60**. The lower end of the spring **64** rests upon the central portion of the spider **24** where the stem **60** passes through a narrow aperture and the upper end is held within the collar **62** so that the spring is extended when the stem **60** is in its uppermost position and compressed when the stem **60** is in its lower positions.

A magnet **68** is mounted in a bore in the lower side of the central portion of the spider **24** and a collar **70** of magnetic material is mounted on the stem **60** so as to be located adjacent to the magnet **68** when the stem **60** is at its uppermost position and to be located at lower positions corresponding to lower positions of the stem. The magnet **68** and the collar **70** cooperate with the spring **64** to resist vacuum pressure in the tank that tends to pull the vacuum pallet **66** downwardly, with the magnet **68** and collar **70** primarily controlling the vacuum pressure limit that first moves the vacuum pallet **66** from its valve seat and the compression spring **64** primarily limiting the distance to which the vacuum pallet **66** is pulled by the vacuum pressure.

To prevent rain, snow, debris and other unwanted substances from being drawn or falling onto the spider **24**, onto the vacuum pallet **66** or into the tank, a cover **72** is mounted over the upper cylindrical section **56** of the inner wall with a centrally located boss **80** of the cover **72** mounted on the top of the centrally located supporting cylinder **28**. The cover **72** includes a convex portion **82** having a center at the boss **80** and a horizontal flange **84**, with the horizontal flange **84** overlying the upper vertical cylindrical section **56** and being held thereto by a plurality of studs and nuts **86** circumferentially spaced around the flange **48**.

To permit air to flow under the cover **72**, the vertical cylindrical section **56** includes a plurality of circumferentially-spaced, horizontal air inlets, one of which is shown at **88**, separated by wall portions **90**, with the air inlets **88** and wall portions **90** being covered by a cylindrical outer screen **92** to prevent solid objects from entering the valve **10**. To prevent rain and small solid particles from entering the valve **10**, a frustum-shaped weather guard **94** extends inwardly and upwardly from the top of the inverted frustum section **54** inside the cylindrical outer screen **92**.

In use, the valve **10** is mounted in a vertical position over the outlet in the horizontal tank wall **16** of the tank, with the valve opening **18** aligned with the outlet of the tank. The valve **18** is especially useful as a breather valve for tanks containing flammable petrole-

um products on marine vessels, to allow pressure balancing when pumping products into the tank.

With the cover **72** removed, selected weights **58** are positioned around the centrally located supporting cylinder **28**. These weights **28** control the area of valve opening in response to the vapor flow or volume in the tank. Whether the weight is light or heavy the area of opening is substantially proportional to the escaping vapor volume or flow from the tank.

After the weights **58** have been positioned around the centrally located supporting cylinder **28**, the cover **72** is replaced. The valve **10** is now ready for use in any weather and operates without further cover during good weather or bad weather and while the ship is in port or under way.

In operation, the valve **10** opens to permit air to enter the tank when the vacuum or negative pressure in the tank is above a predetermined value, and opens to permit fluid to escape when the positive pressure in the tank is above a predetermined value. The predetermined value of vacuum or negative pressure in the tank which opens the valve to permit air to enter the tank is preset in the factory by: (1) the strength of the magnet **68**; (2) the distance of the collar **70** from the magnet **68** when the collar **70** is at its highest position; (3) the selection of a spring with a predetermined resiliency.

Firstly, assume that the valve **10** is closed and the vacuum or negative pressure in the tank is increasing. With the valve **10** closed, the valve stem **60** and the vacuum pallet **66** are in their uppermost positions. In these positions, the spring **64** is extended, the collar **70** is adjacent to and held by the magnet **68**, and the beveled edge of the vacuum pallet **66** is seated on the beveled edge of the inwardly extending annular flange **34** to close the valve element **22**.

When the vacuum or negative pressure reaches the preset value, it exerts sufficient force on the vacuum pallet **66** to pull it and the valve stem **60** downward, with the collar **70** breaking away from the magnet **68**. The force pulling the vacuum pallet **66** downward is resisted by the compression spring **64** so that the vacuum pallet **66** is pulled further by a larger vacuum or negative pressure than by a lower vacuum or negative pressure.

While the vacuum pallet **66** is lowered, air flows into the tank along the following path: (1) through the screen **92** near the top of the valve **10**; (2) through the air inlets **88** and around the weather guard **94**; (3) downwardly through the valve element **20** and between the arms **26** of the spider **24**; (4) around the vacuum pallet **66**; and (5) through the valve opening **18** into the tank, as shown in FIG. **3**.

As the vacuum or negative pressure in the tank decreases, the spring **64** extends to pull the valve stem **60** and the vacuum pallet **66** upwardly. When the collar **70** and the valve stem is pulled near the magnet **68**, the increased magnetic attraction forces the collar **70**, the valve stem **60**, and the vacuum pallet **66** into the closed position with the beveled edge of the vacuum pallet **66** seated on the beveled edge of the inwardly extending flange **34**. With the vacuum pallet **66** in this position, air cannot flow through the valve **10** into the tank.

Secondly, assume that the valve **10** is closed and the pressure in the tank is increasing. With the valve **10** closed, the spider **24**, the outer supporting ring **30**, and the inner wall **52** of the contoured outlet channel **44** are in their lowermost positions. In these positions, the pressure pallet **32** is seated against the annular valve seat **38** at the top of the wall **11** to prevent fluid from entering the contoured outlet channel **44** of the valve.

When the pressure in the tank reaches the preset value, it exerts sufficient force on the valve element **20** to lift it and the weights **58**. As the pressure pallet **32** is lifted by the pressure in the tank, the spider **24** lifts the valve element **20** and the inner wall with the sections **52, 54** and **56**, being guided by the vertically extending guide posts **40** that pass through the apertures in the flange **36** as it moves upwardly.

As the pressure pallet **32** rises, a path for the flow of fluid is provided between the valve opening **18** and the contoured outlet channel **44** as best shown in FIG. **2**. As the inverted frustum section **54** of the inner wall rises, the distance between it and the inwardly turned edge of the outer wall **46** is increased to provide a larger area opening from the contoured outlet channel **44** to the atmosphere.

While the valve element **20** is upward or in its open position, fluid flows from the tank along the following path: (1) from the tank through the valve opening **18**; (2) from the valve opening **18** into the contoured outlet channel **44**; and (3) from the contoured outlet opening **44** to the atmosphere.

The greater the vapor flow from the tank, the higher the valve element **20** is lifted, and the higher the valve element **20** is lifted, the larger the outlet at the end of the contoured outlet channel **44** is because the inverted frustum section **54** of the inner wall is lifted with respect to the inwardly turned end of the outer wall **46**. The increased areas of the outlets results in an increase in the volumetric rate of flow of the fluid.

When the vapor flow from the tank diminishes, the valve element **20** is lowered to reduce the areas of the outlet from the valve opening **18** into the contoured outlet channel **44** and the outlet from the contoured outlet channel **44** to the atmosphere. This reduction in the areas of the outlets enables the velocity of the escaping fluid to remain high until the valve element completely closes even though the pressure in the tank and the volumetric rate of the flow of the fluid are slowly reduced.

In this venting operation, flammable fluids escaping from the valve **10** are controlled to reduce the danger of accidental ignition in two ways, which are: (1) when the pressure in the tank is high the fluid is quickly expelled through a large area outlet into the atmosphere; and (2) a high degree of velocity and turbulence is created and maintained in the escaping fluid to mix it with air and thin it beyond its thin flammability limit so that it does not ignite. The high degree of mixing is provided by the geometry of the contoured outlet channel **44** and by maintaining the velocity of the escaping fluid as the vapor volume in the tank falls.

As shown in FIG. **4**, the fluid leaving the contoured outlet channel **44** forms an upwardly streaming jet with the highest velocity at the core of the stream. The velocity decreases towards the outer sections of the stream because of friction between the vapors and the air, and the greater the friction the better and faster the mixing. FIG. **4** indicates how the velocity of the vapor jet stream diminishes as it mixes with air. The different

velocities are expended in percentage of the maximum velocity of fluid in the jet, with the highest velocity in the center of the stream.

The degree of mixing of the fluid with air is at the highest and the valve **10** maintains a nearly constant velocity of escaping fluid because it has a low blow-down, that is, it closes before the pressure in the tank drops too low. In a valve of the type that opens fully and remains open until the pressure in the tank drops considerably, the exit velocity of the fluid in the jet is much higher when the valve first opens than later because of the great pressure drop. The lower velocity fluid is not mixed with air as fast.

The valve **10** has several advantages, such as (1) it is able to both let air into the tank to relieve vacuum or negative pressure in the tank and to emit fluid from the tank to relieve positive pressure in the tank; and (2) it functions in all weather at all times, both when the ship bearing the tank is in port and when it is under way because it does not require a special cover to protect it against foul weather.

The jet velocity depends on the pressure in the tank and the valve nozzle design. With the pressure drop in the tank, the velocity drops. The velocity drop is slight because the valve reduces the pressure in the tank only slightly, that is, it closes before the pressure in the tank drops too much.

The valve opening area as the valve vents does not depend on the pressure, it depends on the vapor volume or rate of vapor build-up in the tank.

The valve nozzle does not create a turbulence. It releases a smooth jet stream and if it would not be surrounded by atmosphere, the velocity across the stream would be about the same. The friction between the jet stream and the air slows down the outer layers of the jet column while it mixes with the air.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention, but it is understood that this application is to be limited only by the scope of the appended claims.

The invention is hereby claimed as follows:

1. A vertical jet breather valve for a marine vessel tank handling flammable products, said valve comprising, a tubular base defining an inlet opening and adapted to be mounted on a tank for communication therein, an annular pressure pallet seat means at the upper end of the base, an elongated tubular contoured wall means concentric to said pressure pallet seat and extending upwardly from said base, a movable pressure pallet assembly within said contoured wall means including a pressure pallet coacting with said pressure pallet seat means to relieve super-atmospheric pressure within the tank, said assembly being guidably movable along the vertical upward of said base to raise and lower the pressure pallet relative the seat and being gravitationally biased toward said seat, said assembly including a tubular wall means upstanding above the pressure pallet and coacting with the tubular contoured wall means to define an annular outlet channel through which vapor is exhausted from the tank when the pressure pallet is raised from the seat, the opening presented between the pressure pallet and seat as defined by the contour of the contoured wall means varying in relation to the distance between the pressure pallet and seat, and an outwardly flared portion at the upper end of the tubular wall means coacting with the contoured wall means to vary the opening therebetween depending on the rise of the assembly to coact with the opening between the pressure pallet means and seat means in providing substantially constant velocity of exhausting vapor during all open positions of the assembly.

2. The combination as defined in claim **1**, and said assembly including a vacuum pallet seat, a vacuum pallet coacting with said seat to permit air to enter the tank and relieve sub-atmospheric pressure within the tank, and means biasing said vacuum pallet to seated closed position.

3. The combination as defined in claim **2**, wherein said vacuum pallet biasing means includes a return spring and a magnetic unit.

4. A vertical jet breather valve for a tank containing a vapor comprising a valve base having a tubular wall defining a valve opening, an air inlet, a separate vapor outlet, first and second valve seats, an air channel including said air inlet, said first valve seat and said valve opening, a vacuum pallet, said vacuum pallet being mounted for vertical reciprocal movement between said first valve seat and said valve opening, first biasing means coacting with (for biasing) said vacuum pallet for biasing same toward said first valve seat, whereby said vacuum pallet is seated to block said air channel unless the vacuum pressure from the valve opening is above a predetermined value, a vapor channel including said vapor outlet, said second valve seat and said valve opening, a pressure pallet mounted for reciprocal movement between said second valve seat and a position above said second valve seat, and second biasing mans in the form of gravity for biasing said pressure pallet downwardly against said second valve seat, whereby said vapor channel is blocked unless the pressure from said valve opening is above a predetermined value.

5. A vertical jet breather valve as defined in claim **4**, wherein said second valve seat and pressure pallet are substantially horizontal and said vapor outlet includes a substantially horizontal valve outlet and substantially vertically extending outlet channel, said outlet channel communicating with the atmosphere at the upper (one) end and having its lower (other) end terminating lower than at least one portion of said valve outlet, drain means at said lower end, said valve outlet communicating with said valve opening and outlet channel only when said pressure pallet is in said position above said second valve seat, whereby liquids are prevented from flowing through said vapor outlet into said valve opening.

6. A vertical jet breather valve as defined in claim **5**, further comprising a covered hollow casing having side walls and a bottom support member, said hollow casing being mounted for vertical reciprocal movement, said pressure pallet and first valve seat being mounted to said bottom support member for movement therewith, said side walls having horizontal internal walls defining said air inlet whereby liquids are prevented from flowing therein, said bottom support member including apertures aligned with the central portion of said first valve seat whereby air flows through said air inlet, said apertures and said valve opening when the vacuum

pressure from said valve opening is above said predetermined value.

7. A vertical jet breather valve as defined in claim 4, wherein said vapor outlet includes a generally vertical, annular section having an inner and outer wall, said inner wall having an upper section shaped as an inverted frustum whereby said vapor is directed upwardly and radially outwardly from the vapor outlet.

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