March 3, 1964 A. J. GORAND ETAL 3,123,249

VENTING ARRANGEMENTS FOR STORAGE TANKS

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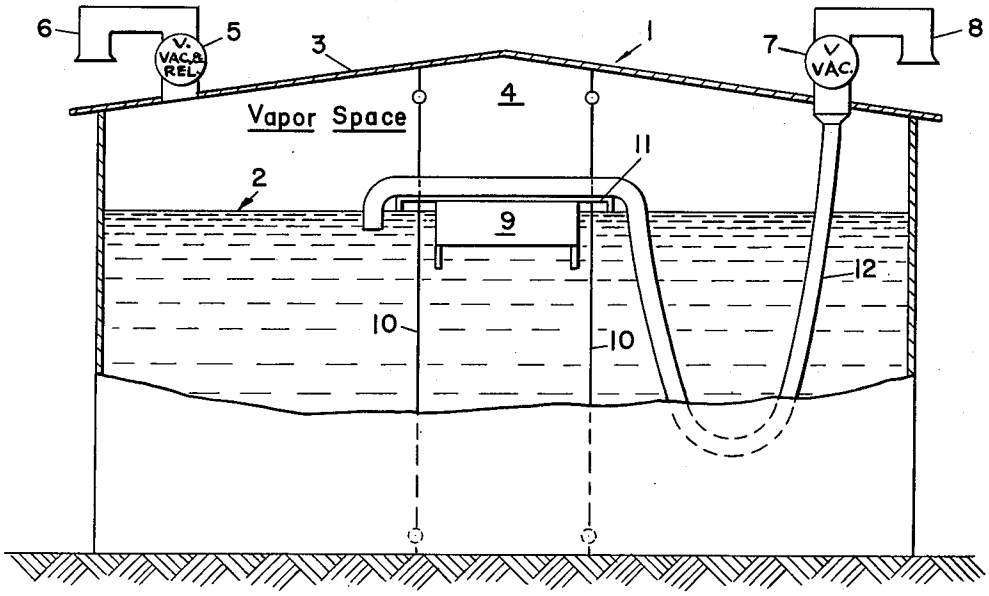


Fig. 1

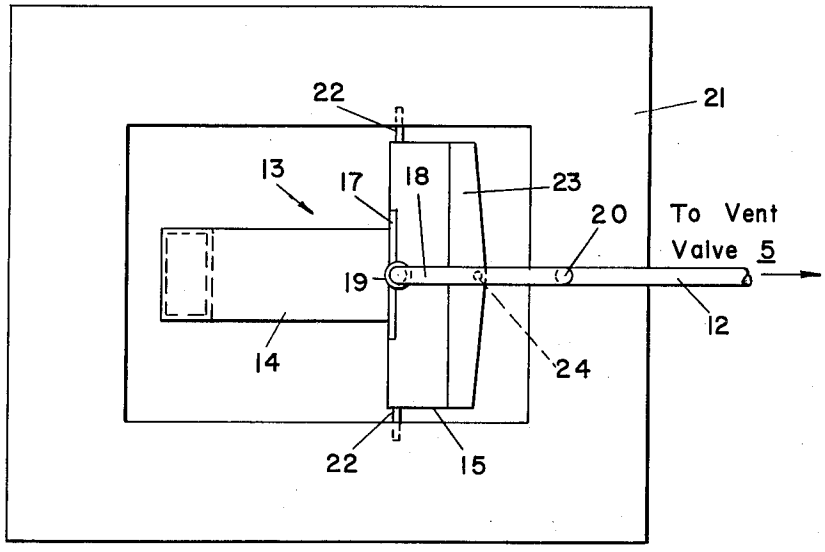


Fig. 2

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Fig. 3

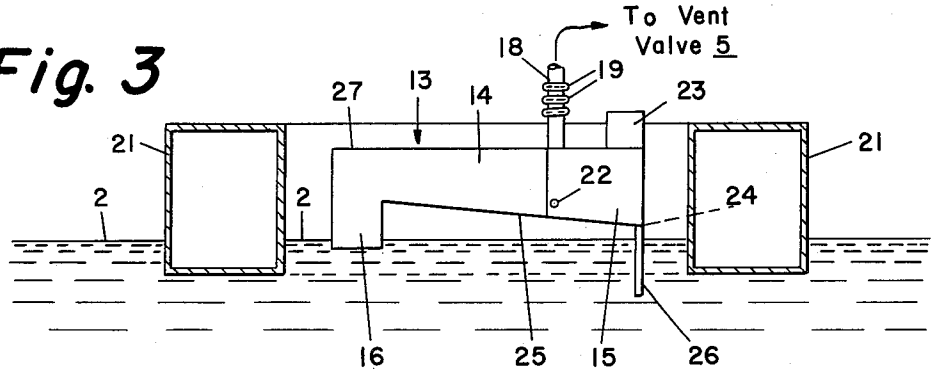


Fig. 4

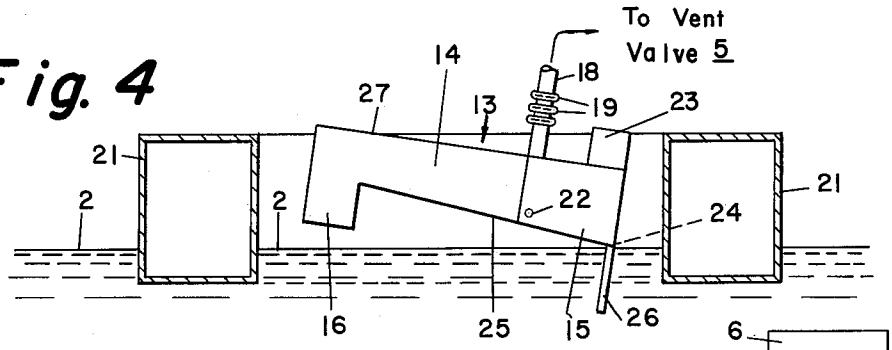


Fig. 5

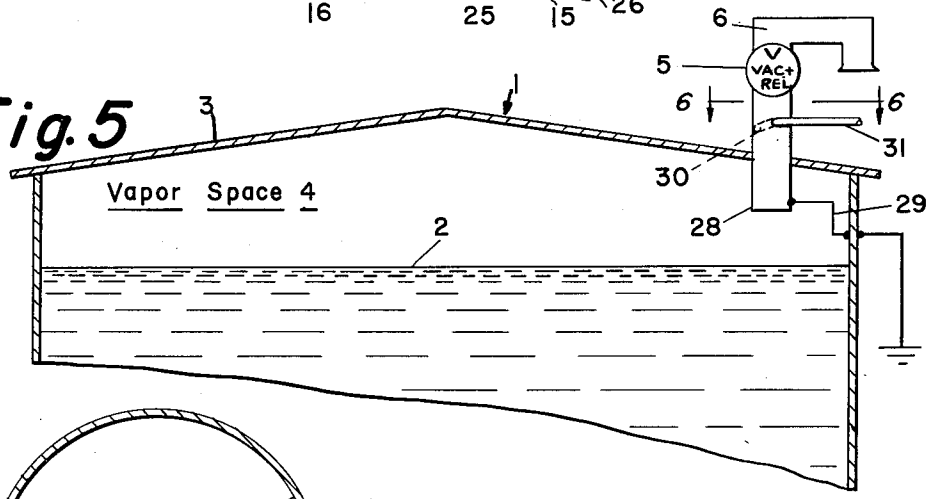
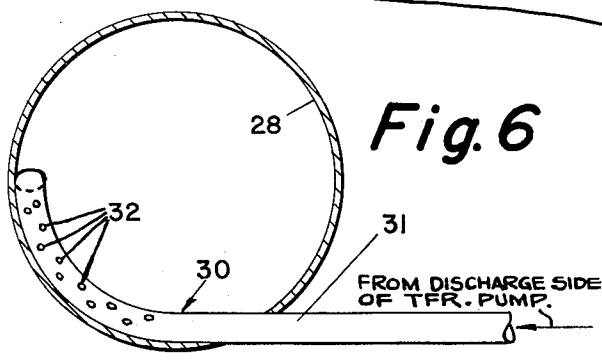


Fig. 6



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VENTING ARRANGEMENTS FOR STORAGE TANKS

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5 Claims. (Cl. 220—85)

This invention relates to venting arrangements for storage tanks in which are being stored volatile and flammable liquids, such as liquid hydrocarbons. Although not limited thereto, the invention has particular utility in connection with the storage of liquids having low or moderate vapor pressures at storage temperatures.

Liquid hydrocarbons are often stored in tanks of the fixed cone-roof type, in which there is a vapor space above the stored liquid. Changes in the pressure existing in the vapor space of such tanks will occur due to changes in the temperature of the vapor and/or liquid (with a concurrent change in volume) in the tank, or due to addition to, or removal of, liquid from the tank. Means are, therefore, required to prevent the differential pressure in the vapor space (i.e., the difference between the pressure in the vapor space of the tank and the pressure of the atmosphere surrounding the tank) from exceeding some specified value. Customarily, such means comprises one or more vent valves, mounted on the roof of the tank. When the pressure in the vapor space of the tank exceeds that of the atmosphere by more than a specified amount, the valve or valves will open to permit the release of sufficient vapor from the vapor space to reduce the pressure to another specified value. When, however, the pressure in the tank vapor space falls below some specified value, the valve or valves will open to permit a gas, or vapor, to flow into the vapor space, thus causing the pressure in the vapor space to rise to a further specified value. The release of vapor from the vapor space may be termed "out-venting," while the flow of gas, or vapor, into the vapor space may be termed "in-venting."

The gas or vapor which is "in-vented" is commonly air, although in some instances it may be an inert gas such as nitrogen. In those cases where air is the "in-vented" medium, and the liquid in the tank is of a flammable nature, such as a hydrocarbon, there always exists the possibility that the partial pressures of the flammable liquid and of the air, in the vapor space, will be so related as to form an explosive mixture in this vapor space. This is undesirable, from the standpoint of safety. This possibility is greatest when atmospheric air is "in-vented," while the aforementioned possibility is quite unlikely when vapor from the vapor space is "out-vented."

An object of this invention is to provide various novel arrangements for the venting of storage tanks.

Another object is to provide various tank-venting arrangements which function to positively prevent the build up of an explosive mixture in the vapor space of the protected tank.

A further object is to provide an arrangement which functions to permit both "in-venting" and "out-venting" of a storage tank, and which operates to prevent the development of an explosive mixture in the vapor space of such tank.

The objects of this invention are accomplished, briefly, in the following manner: In a cone-roof tank provided with a vacuum-relief type of vent valve, a flexible conduit is coupled between the vent valve and a float, the arrangement being such that the float end of the conduit is maintained submerged at a constant predetermined

depth below the surface of the liquid in the tank, irrespective of the level of such liquid. In a modification, a vent valve of the conventional vacuum-pressure type is utilized, and there is provided an arrangement for automatically lifting the submerged end of the conduit above the surface of the liquid in the tank in response to an increase of pressure in the vapor space. In another embodiment, again using a vacuum-relief type of vent valve, a conduit extends between the vent valve and the tank vapor space, and there is utilized means for spraying the stored liquid into this conduit, thereby to cause the air flowing through this conduit to intimately contact such liquid, on its way to the vapor space.

A detailed description of the invention follows, taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a schematic representation of an arrangement according to the invention, as it would appear when looking at the front thereof;

FIG. 2 is a plan view of a modification, showing only the float-supported portion thereof;

FIG. 3 is an approximately central vertical section through the modification of FIG. 2, the pivoted receptacle of this modification being shown in its normal or unoperated position;

FIG. 4 is a view similar to FIG. 3, but showing the receptacle in its operated position;

FIG. 5 is a partial view similar to FIG. 1 but illustrating another embodiment of the invention; and

FIG. 6 is a sectional view taken along line 6—6 of FIG. 5, and drawn on an enlarged scale.

Referring first to FIG. 1, a cone-roof tank is denoted in its entirety by numeral 1. Tank 1 is illustrated schematically since it is of conventional construction. Tank 1 has stored therein a volatile, flammable liquid such as a liquid hydrocarbon, the liquid level being indicated by numeral 2. As is usual with tanks of the cone-roof type, the cone-roof 3 completes the enclosure of a vapor space 4 which is above the stored liquid. The level 2 is of course the lower boundary of the vapor space.

A vent valve 5, which may be of the conventional vacuum-pressure type, is mounted in the roof 3, near one edge thereof, in a standard or conventional U or reentrant fitting 6. The valve 5, illustrated schematically because it is of conventional construction, is coupled at its inner end to the vapor space 4, and is coupled at its outer end to the atmosphere by way of fitting 6. This valve, as mentioned, may operate for both vacuum relief and pressure relief, it being normally closed. That is to say, for vacuum relief it may operate (or open) to admit atmospheric air to the vapor space 4 (thus providing "inventing") in response to a predetermined subatmospheric pressure in such vapor space; for pressure relief it will operate (or open) to allow vapor to pass from the vapor space 4 to the atmosphere (thus providing "out-venting") in response to a predetermined superatmospheric pressure in such vapor space. As will become more apparent hereinafter, it is not necessary that the valve 5 provide for vacuum relief; it may, therefore, be of the pressure-relief type, only.

A vent valve 7, of the vacuum-relief type, is also mounted in roof 3, near the edge thereof and more or less diametrically opposite valve 5, although this location is not essential. Valve 7 is mounted in a conventional U or reentrant fitting 8. Valve 7, illustrated somewhat schematically because it may be of conventional construction, is coupled at its outer end to the atmosphere by way of fitting 8. The inner end of valve 7 faces toward the interior of tank 1. Valve 7 is normally closed, but it operates or opens in response to a predetermined subatmospheric pressure of low value in the vapor space 4, or in

the liquid near level 2. As will be described hereinafter, the inner end of valve 7 is coupled to the liquid near level 2. In this connection, it is desired to be pointed out that the pressure in vapor space 4 is effective on the liquid therebelow.

As stated, valve 7 is arranged to operate (i.e., open) in response to a predetermined subatmospheric pressure at its inner end. If valve 5 is of the vacuum-pressure type, valve 7 is adjusted or set so that it will open at about one-half the subatmospheric pressure at which valve 5 is set to open for vacuum relief. Thus, for "in-venting" or vacuum relief, valve 7 always will open before valve 5, and thus the vacuum relief or "in-venting" will always take place only through valve 7. Of course, if valve 5 is of the pressure-relief type, only, no thought need be given to the relative set or adjustment points of valves 7 and 5.

A float 9, made of a material which is sufficiently buoyant to float on the stored liquid and which is inert to such liquid, is positioned in tank 1. This float is constrained to move in a substantially straight, vertical direction (as liquid level 2 rises or falls) by means of a pair of spaced, vertically-extending guide wires 10 located at opposite sides of float 9 and secured at their respective opposite ends to the roof 3 and to the bottom of the tank 1. A guide member 11, firmly secured to float 9, is arranged to slide up and down on wires 10 (as by means of holes in such member, through which the wires pass), thus constraining the float to move only vertically; that is to say, lateral movement of the float is effectively prevented.

A flexible conduit 12, comprising for example a length of "Neoprene" hose of adequate diameter, has one of its two ends secured to the inner end of valve 7, adjacent or at the cone-roof 3. This upper end of the conduit is sealingly connected to valve 7. The other or lower end of hose 12 approaches guide member 11 and float 9 from the side thereof nearest the valve 7 (which is the right-hand side in FIG. 1), then passes over the top of the float and extends down into the liquid on the opposite or left-hand side of the float. The actual open lower end of hose 12 is located at a predetermined small (for example, one-half inch) depth below the liquid level 2. The portion of hose 12 which passes over float 9 is rigidly secured thereto, so that this portion of the hose moves with the float. Thus, the lower end of conduit 12 is maintained submerged at a predetermined substantially constant depth below the surface 2 of the stored liquid in tank or container 1, irrespective of the level of such liquid; the lower end portion of hose 12 rises and falls with the float, as the level 2 rises and falls. Stating the above in a somewhat simpler way, the conduit means 12 is coupled between valve 7 and a point below the surface 2 of the stored liquid.

The valve 7 is of the vacuum-relief type, as previously stated, and operates for "in-venting" purposes. In response to a predetermined subatmospheric pressure of low value in the vapor space 4, and at the lower end of hose 12 (which lower end is in communication with valve 7 by way of the hose), valve 7 operates or opens to admit atmospheric air to the inner end of the valve. This subatmospheric pressure may come about as a result of withdrawing liquid from the storage tank, or as a result of contraction of the liquid and vapor contents of the tank due to a temperature change. The air so admitted flows down through conduit 12 to the lower end thereof, and from thence travels through the stored liquid (i.e., it bubbles up through the liquid) before it reaches the vapor space 4. This air, bubbling through the liquid, comes into direct, intimate contact with such liquid. As a result, this air tends to become saturated to a certain degree with the stored liquid.

Since the gaseous material already in the vapor space has also been in contact with the relatively volatile liquid contents of the tank, and for an extended period, it will have a composition substantially in equilibrium with the stored liquid. Thus, it will be appreciated that the "in-

vented" stream of gas entering the vapor space will have approximately the same composition as does the material already in the tank vapor space. In this connection, it is pointed out that in air-hydrocarbon vapor mixtures, the mixture can be considered dangerous (from the explosion standpoint) only over a certain finite range of percentage of hydrocarbon vapor in the mixture. The FIG. 1 venting arrangement functions, by saturating the admitted air to a composition approximating that existing in the vapor space, to positively prevent the development of an explosive mixture in the tank 1.

The bubbling of the admitted air through the stored liquid, in the manner described above, produces an additional effect which is desirable. This bubbling agitates the stored liquid in such a way as to destroy the stagnant film which may accumulate, from time to time, at the liquid surface.

It may be noted that, in FIG. 1, the admitted air enters the vapor space 4 at the bottom thereof, due to the lower end of hose 12 being positioned where it is. This feature is desirable, since it tends to combat stratification in the vapor space.

The FIG. 1 arrangement is automatic and self-actuating. Since it needs no services, it is particularly adaptable to storage tanks which are in isolated locations and which are relatively inactive. In this arrangement, the lower end of the flexible conduit or hose 12 is submerged, and hence sealed insofar as "out-venting" of vapor is concerned. Hence, it requires a separate valve 5, installed in the conventional manner, for "out-venting," in addition to the valve 7 which is coupled to the flexible connection 12 (with its submerged end) and which is used for "in-venting."

In FIGS. 2–4, there is disclosed a modification of FIG. 1 which renders unnecessary the second valve; in this modification, the same vent valve (of the vacuum-pressure type) can be used for both "in-venting" and "out-venting." In the said modification, means is provided for automatically unsealing the submerged end of the flexible conduit which is denoted by 12 in FIG. 1. This unsealing action occurs in response to an increase of pressure in the tank vapor space above a predetermined value.

A somewhat general description of the modification of FIGS. 2–4 will now be presented. As pressure in the tank vapor space builds up above a predetermined value, liquid is forced up into the submerged end of the flexible conduit. This liquid flows into an elongated pivoted receptacle supported by the float, and runs to the far end thereof. The weight of the liquid causes the pivoted receptacle to tip or pivot, thus raising the submerged end of the conduit out of the liquid and allowing the vapor to flow into the conduit and out the coupled vent valve, which latter is of the conventional vacuum-pressure type. This provides pressure relief by "out-venting." The pivoted receptacle is provided with a "weep"-type drainhole, so that it is self-draining. When the liquid has drained out of the receptacle by way of this "weep" hole, the pivoted receptacle returns to its original or normal position, returning the (normally submerged) end of the flexible conduit to its submerged position. This reseals the lower end of the flexible conduit. Trace leakage at the vent valve allows the flexible conduit to return to atmospheric pressure. Then, the cycle can be repeated. "In-venting" occurs in the same manner as in FIG. 1.

There are several requirements for a device answering the above general description, as follows:

(1) There must be a minimum of resistance to the motion of the pivoted receptacle. Hence, the connector between the flexible conduit (which couples the receptacle to the vent valve) and the pivoted receptacle must be extremely and readily flexible.

(2) The "weep" drainhole in the bottom of the pivoted

receptacle must be the maximum possible distance from the pivot point, consistent with satisfactory operation.

(3) When the submerged end has been lifted above the liquid surface, the "weep" hole must be above the liquid surface.

(4) The bottom wall of the pivoted receptacle must slope slightly downward, from the upper tip of the submerged end toward the pivot. This is to ensure that liquid forced up the submerged end will run to the far end or back of the pivoted receptacle, where it will have the greatest leverage effect.

(5) The distance from the pivot to the sumberged end should be as great as possible, so that the amount of angular motion of the pivoted receptacle necessary to lift the submerged end out of the liquid may be as small as possible.

(6) The entire pivoted receptacle must move with the surface of the stored liquid in the tank. This is best done by having the device supported by a large float.

To satisfy requirement No. 1 above, the flexible conduit from the vent valve would terminate on the float (see requirement No. 6 above in regard to the float). The connector from this termination into the pivoted receptacle would then be a tube of the same diameter as the flexible conduit to the vent valve, and made of a thin, very flexible material. This tube would be reinforced to resist external pressure (so as to prevent collapse thereof when the pressure in the tank vapor space tends to rise, prior to "out-venting"). The tube could be made from some flexible thermoplastic sheet material (such as polypropylene, polyethylene, vinyl, etc.) which is inert to the liquid in the tank, or it could be made from a fabric impregnated with a material which is inert to the liquid in the tank. The reinforcing could be any stiff material such as piano wire, wound in the form of a spiral. The tube connector may be of any convenient shape. For convenience, the end communicating with the flexible conduit leading to the vent valve (the communication being made on the float, as previously mentioned) should be round. Again for convenience, the end of the connector fastened to the pivoted receptacle should preferably be flat (as will become apparent hereinafter), with the same cross-section as the round end (i.e., the other end).

So that there will be a minimum of movement of the connector, the opening therefor into the pivoted receptacle should be in the same vertical plane as the pivots. To reduce the dimensions of the device, a flat lower end for the flexible connector is desirable, if sufficient flexible reinforcement can be provided.

Requirements Nos. 2 and 3 above are contradictory in some measure. Requirement No. 5 further complicates matters. The following discussion, however, tends to clarify the situation.

By properly counterweighting the "weep" drainhole end of the pivoted receptacle, this end can be made quite short. Thus, the required amount of movement of such drainhole may be minimized. This will, in turn, minimize the distance the drainhole must be above the surface when the opposite end is submerged. Likewise, this will permit the device to function for "out-venting" at a lower positive pressure, from a practical standpoint. The relation between the position of the drainhole and the positive pressure required for "out-venting" will be explained hereinafter.

The discussion in the preceding paragraph has thus reconciled requirements No. 3 and No. 5 above.

With regard to requirement No. 2 above, this should be interpreted to mean at the extreme dimension of the pivoted receptacle. The best design would result if the drainhole end were slightly tapered, say 5° to 10°, from each side toward the center, such that the total length of the receptacle is greatest at the center. With the drainhole located at the center, the drainhole would then be at the low point when the submerged end is lifted above the surface.

To provide a seal for "in-venting," such that the admitted air will pass down through the receptacle and out the submerged end similarly to FIG. 1, rather than out through the drainhole, the latter should be provided with a tube, which may be termed a drain tube, extending downwardly into the liquid to a point below the lower tip of the submerged end.

The constructional details of the modified construction of FIGS. 2–4 will now be described, keeping in mind the foregoing discussion regarding this construction. A receptacle, denoted generally by numeral 13, is shaped like the block capital letter T (see FIG. 2), and both the upright 14 and the cross-bar of the T have a roughly rectangular cross-section. Receptacle 13 may be formed, for example, from thin sheet metal stock, so that it is relatively light in weight. Receptacle 13 is mainly of uniform height, and is positioned to be normally substantially horizontal and parallel to the liquid level 2 (see FIG. 3). How this receptacle is supported in position will be described hereinafter. The free end of the upright 14 of the T has an integral extension 16 which extends downwardly from the main body of the receptacle (see FIG. 3). This extension is open at its lower end and is normally located a predetermined small distance (such as ½") below the tank liquid level 2. The cross-sectional area of extension 16 is equal to that of the main body of the receptacle.

In the upper wall of the cross-bar 15 of the T, there is provided a rectangular aperture 17 which is rather long in the direction of the length of the cross-bar but quite narrow in the transverse direction. One of the long sides of aperture 17 coincides with that edge of the cross-bar 15 which is joined to the upright 14. One end of a flexible connector 18, which is made for example from a flexible thermoplastic sheet material, is flattened to a rectangular cross-section conforming to aperture 17, and is sealed to such aperture at its upper face. Connector 18 is reinforced as indicated at 19, this reinforcing being provided by any suitable stiff material, preferably fashioned in the form of a spiral.

Connector 18 extends upwardly from receptacle 13 for a short distance, then horizontally in a direction away from the upright 14 (see FIG. 2), to a termination or junction 20 which is located on the upper surface of a float 21 in the shape of a hollow square, or other convenient shape. The end of connector 18 at the junction 20 is round, and has the same cross-sectional area as the end of this connector at aperture 17. The junction 20 is attached to float 21, so as to be supported thereby. At the junction 20, connector 18 is sealingly coupled to the lower end of a flexible conduit 12 which may be similar to conduit 12 in FIG. 1. The lower end of conduit 12 is round and has the same cross-section as the coupled end of connector 18. The float 21, by means of the junction 20 previously described, directly supports the weight of conduit or hose 12.

The upper end of conduit 12 extends to a vent valve of the conventional vacuum-pressure relief type which is mounted in the cone-roof of the tank; this valve may be similar to valve 5 in FIG. 1 and may function for both "in-venting" and "out-venting." It may be seen that, by way of aperture 17, flexible connector 18, and conduit 12, the vent valve referred to is coupled to the interior of receptacle 13, and to the submerged end 16 thereof.

Receptacle 13, together with connector 18, is supported by float 21. Receptacle 13 is pivotally mounted on float 21 by means of two pivot pins 22 fixedly secured to respective opposite ends of the cross-bar 15 and journaled for rotation in float 21, at respective opposite sides of the hollow portion of this float. Pivot pins 22 are centered on the center line of aperture 17 (see FIG. 2). The entire receptacle 13 is positioned within the confines of the hollow portion of the hollow-square-shaped float 21. By

means of pins 22, the receptacle 13 is supported by float 21, and is mounted for pivotal movement with respect to this float.

A counterweight 23 is fixedly secured to the top wall of cross-bar 15, at the rear end of this cross-bar, i.e. at the end thereof remote from upright 14. This counterweight extends from one end to the other of the cross-bar 15, i.e. entirely across the same (see FIG. 2).

The rear end of cross-bar 15 is slightly "fattened," from each side to the center line of the upright 14; that is to say, this end of the cross-bar is slightly tapered, from each side toward the center. A "weep" drainhole 24 is provided in the bottom wall 25 of the receptacle in the cross-bar 15, this hole being located at the rear end of the cross-bar and on the center line of the upright 14, that is, at the "fattest" point of the cross-bar 15. A drain tube 26 is sealed into "weep" hole 24 and extends downwardly from the receptacle bottom wall 25, to a point a suitable distance below the bottom of the submerged end extension 16.

The bottom wall 25 of the receptacles (in vertical cross-section, see also FIG. 3) slopes or inclines downwardly, from the upper end of the submerged end extension 16 toward the drainhole 24. Since the drainhole is at the "fattest" point of the cross-bar 15 (and thus at the greatest distance from end extension 16), this hole is at the lowest point of the receptacle.

The top wall 27 of the receptacle (in vertical cross-section, see also FIG. 3) is level, i.e. it does not slope.

With the receptacle 13 in its normal or unoperated position illustrated in FIG. 3, that is, with the end 16 of the receptacle submerged below the liquid surface 2, "in-venting" can take place in the same manner as in FIG. 1, with the admitted air from the vacuum relief vent valve reaching the liquid by way of flexible conduit 12, connector 18, and the interior of receptacle 13; this air issues from the submerged end 16 and bubbles up through the liquid to the vapor space thereabove, vapor enrichment thereby taking place in the same manner as previously described in connection with FIG. 1.

When the pressure, in the vapor space of the tank in which the device of FIGS. 2–4 is being used, builds up above a predetermined value, liquid will be forced up into the submerged end 16 of the receptacle 13. This liquid runs along the inclined bottom wall 25 of the pivoted receptacle to the opposite end thereof. The weight of the liquid causes the pivoted receptacle to tip or rotate in the clockwise direction about its pivots 22, thus raising the (hitherto submerged) end 16 out of the liquid, and allowing the vapor to flow to the pressure relief vent valve by way of receptacle 13, connector 18, and flexible conduit 12. "Out-venting" can thus take place in the manner just described. See FIG. 4, which illustrates the receptacle in its tipped or operated position, as just described.

The relation between the position of the drainhole 24 and the positive pressure required for "out-venting" will now be explained. When the device is in the position shown in FIG. 3, it is desirable that the upper end of integral extension or end 16 be as close as possible to liquid level 2. This distance will determine the lowest pressure at which "out-venting" can occur, since, until the liquid has been forced up to this point, the receptacle 13 will not pivot to lift the lower end of extension 16 above the surface 2 (thereby to open the tank vapor space to vent valve 5). The less the distance between liquid level 2 and the upper end of extension 16, the lower will be the pressure at which "out-venting" occurs.

However, requirement No. 4 above states that the bottom wall 25 of receptacle 13 must slope. Hence the closer the drainhole 24 is to pivots 22, the less will need to be the magnitude of the slope. Thus, for a given positive slope of the bottom wall 25, the closer the drainhole 24 is to the pivots 22, the smaller will be the distance of the upper end of extension 16 above liquid level 2.

The receptacle 13 is self-draining, because of the "weep" drain hole 24. When the liquid has drained out of the receptacle by way of this drainhole and drain tube 26, the pivoted receptacle tips or pivots in the counter-clockwise direction, returning to its original position (illustrated in FIG. 3) and resealing the end 16 (i.e., resubmerging it below the liquid surface).

From the foregoing, it may be seen that with the modified construction of FIGS. 2–4, the same vent valve (of the vacuum-pressure relief type) can be used for both "in-venting" and "out-venting," the upper end of the flexible conduit 12 being coupled to such valve.

It should be noted that the flat, rectangular structure described above in connection with FIGS. 2–4 would be satisfactory only if the pressure at which "out-venting" was made to occur was relatively low, on the order of five inches of water or less, with light sheet metal construction. This follows since the dimensions of the T, for practical purposes, would be such that the areas of the flat sides (for a rectangular cross-section) would be substantial. Further, the internal pressure in the T will be approximately atmospheric. Thus, just prior to "out-venting," these flat, unsupported surfaces must withstand the entire pressure differential. Since the flat surfaces will be thin sheet metal, their ability to withstand such forces is limited.

Instead of a roughly rectangular cross-section (for the receptacle) as previously described, both the upright 14 and the cross-bar 15 of the T could be of circular cross-section. The same general principles of design would apply. This circular cross-section design would raise the maximum "out-venting" pressure above the limit set out in the preceding paragraph. A change to a circular cross-section lessens the problem mentioned in the preceding paragraph, since a hollow cylinder will withstand a much greater external pressure than a rectangular box of the same cross-section and wall thickness.

FIGS. 5 and 6 illustrate another embodiment of the invention, which also operates to produce a saturated vapor in the vapor space of a cone-roof tank. In this embodiment, a vent valve 5, for example of the conventional vacuum-pressure type, is mounted in the cone-roof 3, near one edge thereof, in a U or reentrant fitting 6. The valve 5 is coupled at its inner or tank end to the tank vapor space 4 by means of a large-diameter pipe 28 whose inner end extends down into the tank vapor space. The lower or inner end of pipe 28, inside the tank 1, is electrically bonded to the cylindrical (grounded) wall of the tank by means of a metallic conductor 29 which serves as a means to bleed off static electrical charges from the lower end of pipe 28.

A device 30 which may be termed a "saturator" is mounted within pipe 28, on the tank side of the vent valve 5 but outside (above) the cone-roof 3. The "saturator" is located at one end of a pipe 31 of small diameter (½", for example) which approaches pipe 28 from one side thereof, in a more or less tangential direction (see FIG. 6). The end of pipe 31 extends into the interior of pipe 28, and then bends around the inner wall of pipe 28, and also downwardly, terminating about 90° angularly from the point of entry of pipe 31 into pipe 28 (see FIG. 6). The end of pipe 31 is closed, but near its end it has through its side wall a multiplicity of small apertures 32 which point more or less radially of pipe 28. The arrangement of pipe 31 is such that any liquid flowing therethrough will be sprayed into the interior of pipe 28 in the form of fine droplets, the form of pipe 31 producing a swirling action of the liquid spray within pipe 28.

A stream of the tank contents is supplied to the "saturator," so as to produce a spray of the flammable liquid inside the pipe 28. During "in-venting," when the valve 5 is functioning as a vacuum relief valve, the atmospheric air admitted to the tank vapor space by means of this valve (when the valve is open) flows through pipe 28

and comes into intimate contact with the liquid which is present in the form of a fine spray in pipe 28. The air, intimately contacting the liquid, tends to become saturated to a certain degree with the stored liquid on its way to the vapor space 4, and before it reaches such space. The action here is quite similar to that described previously, in connection with FIG. 1. The "in-vented" or admitted air is saturated to a composition approximating that existing in the vapor space, thus preventing the development of an explosive mixture in tank 1. From the foregoing, the use of the descriptive term "saturator" may be appreciated.

Since the major problem, as stated hereinabove, is saturating "in-vented" air, and since the major occurrence of "in-venting," for active tanks at least, is when pumping liquid out of the tank 1, the necessary supply of tank contents to the "saturator" 30 is effected by taking a drag stream from the discharge side of the liquid transfer pump, for application to pipe 31. It may therefore be seen that the embodiment of FIGS. 5–6 is most applicable to active tanks, such as "run" tanks, surge tanks, etc.

It may be noted that the embodiment of FIGS. 5–6 requires only one vent valve, for both vacuum and pressure relief. However, it does require a means for supplying liquid to the "saturator," which means can be, as stated, a connection from the discharge side of the liquid transfer pump to pipe 31.

On the other hand, it may be noted that the installation of a separate small pump, the operation of which is controlled automatically by suitable instrumentation and which is supplied with liquid from the tank, would permit the use of the embodiment of FIGS. 5 and 6 for relatively inactive tanks. The instrumentation would be based on the pressure in the vapor space of the tank. When the pressure in the vapor space became less than some predetermined value, the instrumentation would start the pump. When the pressure in the tank vapor space rose to a predetermined value, it would shut the pump off.

The invention claimed is:

1. In combination, a container for storing a volatile liquid, said container being constructed and arranged to enclose a vapor space above the stored liquid; a vent valve of the vacuum-pressure type, a conduit having one end secured to said valve and having its other end extending below the surface of the stored liquid, and means operating in response to an increase of pressure in said vapor space to lift said other end of said conduit above the surface of the stored liquid.

2. In combination, a container for storing a volatile liquid, said container being constructed and arranged to enclose a vapor space above the stored liquid; a vent valve of the vacuum-pressure type, a flexible conduit having one end secured to said valve and its other end

mounted on a float positioned in said liquid, in such a manner as to normally maintain said other end of said conduit submerged at a predetermined substantially constant depth below the surface of the stored liquid, and means, associated with said conduit and said float, operating in response to an increase of vapor pressure in said vapor space to lift said other end of said conduit above the surface of the stored liquid.

3. In combination, a container for storing a volatile liquid, said container being constructed and arranged to enclose a vapor space above the stored liquid; a vent valve of the vacuum-pressure type, a float positioned in said liquid, an elongated receptacle pivotally mounted on said float for rotation about a substantially horizontal axis, and a conduit communicating at one end with said valve and at its other end with said receptacle, one end of said receptacle having coupled thereto an open-ended extension which normally projects below the surface of the stored liquid.

4. In combination, a container for storing a volatile liquid, said container being constructed and arranged to enclose a vapor space above the stored liquid; a vent valve of the vacuum-pressure type, a float positioned in said liquid, an elongated receptacle, means pivotally mounting said receptacle on said float for rotation about a substantially horizontal axis, said means being coupled to said receptacle intermediate the ends thereof, and a conduit communicating at one end with said valve and at its other end with said receptacle, one end of said receptacle having coupled thereto an open-ended extension which normally projects below the surface of the stored liquid, and the other end of said receptacle having therein a drain aperture.

5. In combination, a cone-roof tank for storing a volatile liquid, a vent valve of the vacuum-pressure type mounted in the cone-roof, a conduit having one end secured to said valve and having its other end extending below the surface of the stored liquid, and means operating in response to an increase of pressure in the vapor space above the stored liquid to lift said other end of said conduit above the surface of the stored liquid.

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