

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) PRESSURE RELIEF VALVE

(71) We, UNION CARBIDE CORPORATION, a corporation organised and existing under the laws of the state of New York, United States of America, residing at 270, Park Avenue, New York, State of New York, 10017, United States of America, (assignee of HELMUT KASPAR AMTHOR), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a pressure relief vent valve useful for relieving high internal gas pressures from inside a fluid-tight sealed container. More specifically, the invention relates to improvements in resealable pressure relief vent valves provided in sealed alkaline galvanic cells for preventing the build-up of high internal gas pressures inside the cell container.

Alkaline galvanic cells may generate large quantities of gas under certain conditions during use. Since these cells are required to be fluid-tightly sealed at all times in order to prevent loss of electrolyte by leakage or evaporation, high internal gas pressures may develop. Such pressures may cause leakage, bulging or possible explosion of the cell if not properly vented. Especially in the case of secondary or rechargeable cells, the vent must be resealable in order to avoid drying out of the electrolyte over the normally long life of the cells and to prevent ingress of oxygen and carbon dioxide.

In the past, several different types of resealable pressure relief vent valves have been used for releasing high internal gas pressures from inside a sealed alkaline galvanic cell. One type of valve that has been commonly used consists basically of a valve member such as a flat rubber gasket which is biased into sealing position over a vent orifice by means of a resilient member such as a helical spring. The resilient

member or spring is set to yield at a certain predetermined internal gas pressure momentarily breaking the seal and allowing the gas to escape through the vent orifice.

Another type of resealable pressure relief vent valve that has been tried is that disclosed and claimed in U.S. Patent 3,293,081 issued to J. L. S. Daley on December 20, 1966. This resealable vent valve basically includes an annular seal gasket such as an O-ring which is maintained in sealing position around the periphery of the vent orifice by means of an arc-shaped resilient member or spring. The resilient member or spring is set to yield and permit radial movement of the seal gasket momentarily breaking the seal and allowing the passage of gas through the vent orifice when a predetermined high internal gas pressure is reached inside the cell.

A major problem encountered with resealable pressure relief vent valves of the type just described is that they are bulky and consequently difficult to incorporate into the cell assembly. Furthermore, these pressure relief vent valves are expensive to manufacture and are not at all adaptable for incorporation into miniature size cells.

According to one aspect of the invention there is provided a pressure relief vent valve for releasing gas from inside a fluid-tight container, which comprises a resilient deformable ball of an elastomeric material force-fitted into a smaller size vent orifice provided within a portion of said container, said ball being compressed and deformed into a substantially elongated configuration within said vent orifice such that the resilient stress of said ball exerts a high sealing force against the side walls of said orifice, said ball being expelled from said vent orifice upon the build-up of an abnormally high internal gas pressure inside said container.

The invention also provides an alkaline galvanic cell incorporating such a pressure

relief valve. The pressure relief vent valve of the invention automatically opens upon the build-up of a predetermined high internal gas pressure inside the cell and then reseals once the pressure has been relieved.

It is an advantage of the invention that the valve is simple and compact and employs a minimum number of parts, is reliable and can be so assembled as to be responsible to a given gas pressure over a wide range of pressures, is inexpensive to manufacture and can be easily adapted to incorporation within nearly all sizes of cells including miniature size cells.

According to the invention an alkaline galvanic cell incorporates a so-called "two-mode" version of the pressure relief vent valve wherein the resilient deformable ball of elastomeric material is positioned within a deep vent orifice by forcing or pressing the ball through the opening of the vent orifice and exerts an initial high sealing force against the side walls of the vent orifice, sealing of the passageway through the vent orifice from inside the cell. The vent valve will remain closed with the resilient ball positioned within the vent orifice until the ball is expelled from the vent orifice by the build-up of an abnormally high internal gas pressure inside the cell. The resilient ball upon being expelled from the vent orifice allows some of the gas to escape from inside the cell but is thereafter caused to seat over the opening of the vent orifice by a retainer means.

The retainer means is positioned over the resilient ball for maintaining the ball in place over the vent orifice and in contact with a valve seat provided around the inner peripheral edge portions of the vent orifice and for compressing and deforming the resilient ball into a flattened configuration forming a normally fluid-tight seal between the flattened ball and the valve seat. The resilient ball is capable of undergoing further temporary deformation upon the build-up of a predetermined high internal gas pressure inside the container momentarily breaking the seal and allowing gas to escape through the vent orifice.

This "two-mode" version of the pressure relief vent valve of the invention is advantageous in that the valve can be set during manufacture of the cell to initially vent in its first mode of operation at a substantially higher pressure than the relatively low pressures at which the valve is operable in its second mode to vent and release gas pressure during normal use of the cell. During storage of the cell, the pressure relief vent valve will not open and vent until an abnormally high internal gas pressure is developed and thus the cell is protected against loss of moisture or water

vapor which can result in drying out of the cell.

In the accompanying drawings:

Figure 1 is an elevational, partially sectioned view of a typical alkaline galvanic cell incorporating the pressure relief vent valve of the invention;

Figure 2 is an enlarged sectional view of the upper portion of the cell shown in Figure 1;

Figure 3 is an enlarged sectional view of the lower bottom portion of the cell shown in Figure 1 and illustrates a different embodiment of the invention;

Figure 4 is a sectional view of the upper portion of a miniature size cell illustrating still another embodiment of the invention;

Figure 5 is a sectional view of the upper portion of a similar cell illustrating still another embodiment of the invention; and

Figure 6 is a sectional view of the lower portion of a cell similar to that shown in Figure 1 and illustrating a further embodiment of the invention.

Referring now to the drawings in detail, there is shown in Figures 1 and 2 a typical alkaline galvanic cell incorporating a pressure relief vent valve in accordance with the invention. The cell comprises an inverted metallic cupped container 10 provided with an outer metallic jacket 11 separated from the container 10 by an insulating liner 12 suitably of paper or other fibrous material. Disposed within the container 10 is a tubular anode 14 and a tubular cathode 15 and an alkaline electrolyte 16 suitably an aqueous solution of potassium or sodium hydroxide. The cathode 15 is juxtaposed in contact with the side walls of the container 10 but is separated from the anode 14 by a liquid and gas permeable, electrolyte-containing separator medium 18. The separator medium 18 may be composed of two juxtaposed layers of separator material placed between the anode 14 and cathode 15 and underlying the upper closed end of the container 10.

Suitably, the cell closure for this cell is of the type disclosed and claimed in U.S. Patent No. 3,042,734 issued to J. L. S. Daley on February 15, 1960. Such a cell closure comprises a generally U-shaped annular seal gasket 20 for sealing the open end of the polarized cupped container 10, an unpolarized rigid metallic cover 21 which resides within the U-shaped annular seal gasket 20 and an oppositely polarized, centrally located terminal rivet 22 which is in contact with an anode current collector 23. The seal gasket 20 is preferably made of a relatively hard non-cold-flowable plastic material such as nylon and is radially compressed between the terminal rivet 22 and the

metallic cover 21 and between the cover 21 and the lower peripheral edges of the container 10, thereby resulting in an extremely leak resistant fluid-tight sealed cell.

5 A metallic top cover plate 24 is provided for the cell and is formed with a central protuberance 25 serving as the positive terminal of the cell. The top cover plate 24 is provided with a vent hole 26 and is also
10 formed with a peripheral ring portion 27 which is fitted tightly around the upper peripheral edges of the container 10 and is compressed or squeezed radially inwardly to provide a smooth juncture between the ring
15 portion 27 and the side walls of the container 10. The metallic jacket 12 is locked in place around the upper and lower extremities of the cell by crimping its upper peripheral edges around the outer edges of
20 the top cover plate 24 and by crimping its lower edges around the outer edges of a metallic bottom plate 28. The bottom plate 28 is maintained in electrical contact with the terminal rivet 22 and serves as the
25 negative terminal of the cell.

The preferred "two-mode" version of the pressure relief vent valve used in the cell of Figures 1 and 2 includes a resilient ball 30
30 force-fitted or pressed into a smaller size circular vent orifice 32 formed within the upper closed end of the container 10. The resilient ball 30 is of an initial spherical shape but is compressed and deformed into an
35 elongated or cylindro-spherical configuration when force-fitted or pressed into the vent orifice 32. The vent orifice 32 is positioned to reside just beneath the central protuberance 25 provided on the top cover
40 plate 24 and is formed with upwardly extending cylindrical side walls of a sufficient depth to provide a fairly deep hole to contain the elongated ball 30. It will be seen that the ball 30 is placed under resilient
45 stress when force-fitted or pressed into the vent orifice 32 and exerts an initial high sealing force against the side walls of the vent orifice 32, sealing off the passageway through the vent orifice 32.

50 During the period that the cell is placed in storage, the pressure relief vent valve will remain sealed with the resilient elongated ball 30 positioned within the vent orifice 32 until the ball 30 is expelled from the vent
55 orifice 32 by the build-up of an abnormally high internal gas pressure inside the cell. The top cover plate 24 and the central protuberance 25 are so designed that the space or gap between the bottom wall
60 portion of the protuberance 25 and the upper peripheral edges of the vent orifice 32 is less than the diameter of the resilient ball 30 in its initial spherical shape prior to being force-fitted or pressed into the vent orifice 32. Thus, it will be seen that the ball 30 when
65 expelled from the vent orifice 32 im-

mediately comes into contact with the flat bottom wall portion of the protuberance 25 which acts as a retainer means for the ball 30 and is compressed and deformed into a
70 flattened configuration but in this instance the ball 30 is in a position overlying the vent orifice 32 as shown in phantom lines in Figures 1 and 2. The resilient ball 30 upon
75 first being expelled from the vent orifice 32 is compressed and deformed to such an extent by the abnormally high internal gas pressure inside the cell that the ball 30 does not immediately seat with the peripheral
80 edge portions of the vent orifice 32 providing an open passageway around the ball 30 for venting gas from inside the cell. The gas follows a path through the vent orifice 32 around the ball 30 and out through the vent hole 26 provided in the top cover
85 plate 24.

Once the initial abnormally high internal gas pressure has been relieved, the resilient stress exerted by the flattened ball 30 forces the ball 30 into a normally fluid-tight seal
90 engagement around the peripheral edge portions of the vent orifice 32 forming a valve seat. The vent valve will remain closed sealing off the vent orifice 32 until the internal gas pressure during use or discharge of the cell builds up to some predetermined
95 value which is less than the abnormally high pressure at which the resilient ball 30 is expelled from the vent orifice 32. When this predetermined gas pressure is reached, the ball 30 will undergo further temporary
100 deformation, momentarily breaking the seal around the peripheral edge portions of the vent orifice 32 and allowing gas to escape from inside the cell in the same manner as just described. The valve will remain open
105 until the forces exerted against the ball 30 by the internal gas pressure are less than the sealing forces exerted by the resilient stress of the ball 30 whereupon the ball will again reseat against the peripheral edge portions
110 of the vent orifice 32 and reseal the valve.

It will be readily seen that the preferred "two-mode" version of the pressure relief vent valve of the invention offers the advantage in that the cell can be maintained in
115 hermetically sealed condition during the period of storage and thereby prolongs the storage life of the cell. It may be noted that during use or discharge of the cell, the internal gas pressure which can develop
120 inside the cell usually builds up quite rapidly and it is most advantageous to vent the gas as soon as possible at fairly low venting pressures. During the period of storage, however, any internal gas pressure which may develop builds up at a slower rate and frequent gas venting at low pressures is not
125 required. Venting at frequent intervals may in fact be detrimental since such venting may be accompanied by loss of moisture or
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water vapor which could result in drying out of the cell. With the preferred "two-mode" version of the pressure relief vent valve of the invention, the valve will not open to vent gas during the period of storage at the relatively low venting pressures for which the valve is operable to vent gas during discharge of the cell and will remain closed until an abnormally high internal gas pressure is reached which should be relieved in order to prevent the possibility of cell explosion.

Figure 3 shows a different embodiment of the invention wherein the "two-mode" version of the pressure relief vent valve is incorporated within the cell closure at the bottom of the cell. The resilient ball 34 is force-fitted or pressed into a fairly deep circular vent orifice 35 provided within the terminal rivet 22. The rivet head portion of the terminal rivet 22 is formed with an enlarged circular recess 36 for receiving the resilient ball 34 when it is expelled from within the vent orifice 35. A disc-shaped spring member 38 is positioned in contact against the rivet head and overlies the circular recess 36 being biased into resilient contact at its outer peripheral edges against a metallic bottom cover plate 40 provided with a vent hole 41. The depth of the circular recess 36 is such that the resilient ball 34 when expelled from the vent orifice 35 is maintained by the spring member 38 in a flattened configuration overlying the vent orifice 35 as shown in phantom lines in Figure 3 and forming a normally fluid-tight seal around the peripheral edge portions of the vent orifice 35. The spring member 38 in this embodiment acts both as a retainer means for the resilient flattened ball 34 upon being expelled from the vent orifice 35 and as a means for maintaining electrical contact between the terminal rivet 22 and the metallic bottom cover plate 40 serving as the negative terminal of the cell.

Figure 4 illustrates another embodiment of the invention which is useful for incorporating the pressure relief vent valve into a miniature size cell. The cell comprises a metallic container 50 having its upper open end sealed by a generally L-shaped annular seal gasket 51 suitably of a relatively hard insulating plastic material. A polarized metallic cover 52 resides within the L-shaped annular seal gasket 51 and is formed with a downwardly depending central stem portion 53 which fits through the opening in the seal gasket 51. An electrical conductor member 54 such as a metallic pin is welded or otherwise secured to the central stem portion 53 and makes electrical connection with one of the electrodes of the cell. A metallic terminal cap 55 provided with a vent hole 56 is positioned over the metallic cover 52 and has its lower peripheral edges

locked in place by a peripheral bead flange 57 formed around the outer peripheral edges of the metallic cover 52. The seal gasket 51 is radially compressed between the metallic cover 52 and the container 10 and the upper peripheral edges of the container 10 are crimped over a seal ring 58 suitably of a relatively soft resilient plastics material.

The "two-mode" version of the pressure relief vent valve of this embodiment includes a resilient ball 60 which is force-fitted or pressed into a deep vent orifice 62 provided within the central stem portion 53. As in the case of the previously described embodiments of the vent valve, the resilient ball 60 is compressed and deformed into an elongated or cylindro-spherical configuration when force-fitted or pressed into the vent orifice 62 forming a high pressure seal. The space or gap between the metallic terminal cap 55 and the peripheral edge portions of the vent orifice 62 is such that the ball 60 is maintained in a flattened configuration as shown in phantom lines in Figure 5 when the ball is expelled from within the vent orifice 62.

The embodiment of the invention illustrated in Figure 5 is basically the same as that just described, except that the vent orifice 62 is formed with a conical shaped valve seat around its peripheral edge portions as indicated at 63. Thus, the resilient ball 60 when expelled from the vent orifice 62 is retained by the metallic terminal cap 55 in a flattened conical configuration against the conical surfaces 63 around the opening of the vent orifice 62 forming the valve seat. It will be seen that in this embodiment of the invention, the resilient ball 60 is compressed to a degree which is somewhat less than when the ball is deformed to a flattened configuration as in the previous embodiments described and that, therefore, the vent valve is capable of venting gas at substantially lower internal gas pressures from inside the cell. It will also be noted in this embodiment that the cell is of the same basic construction as that illustrated in Figure 4 except that the upper peripheral edges of the container 10 are crimped over the upper edges of an L-shaped annular seal gasket 64.

Figure 6 illustrates still another embodiment of the invention incorporating the "two-mode" version of the pressure relief vent valve which can be used in the same type of cell construction as that illustrated in Figure 3. The cell includes an inverted polarized metallic cup container 65 provided with an outer metallic jacket 66 separated from the container 65 by an insulating liner 67 suitably of paper or other fibrous material. The open end of the container 65 is sealed by a rigid annular

insulating cover 68 suitably of a relatively hard plastic material. The peripheral edge portion of the annular insulating cover 68 abuts against the side walls of the container 65 which are radially compressed inwardly to provide a fluid-tight seal juncture between the cover 68 and the container 65. The lower peripheral edges of the container 65 are crimped over a peripheral bead or flange 69 formed integrally around the outer edges of the insulating cover 68. The metallic jacket 66 and the insulating liner 67 extend beyond the lower extremities of the container 65 and are similarly crimped over the outer edges of a metallic bottom cover plate 70 which serves as the negative terminal of the cell.

The pressure relief vent valve used in this embodiment of the invention includes an inverted metallic cup 71 which resides within a shallow circular recess 72 formed within the annular insulating cover 68. The cup 71 is provided with a central upwardly extending cylindrical stem or sleeve portion 73 which is fluid-tightly fitted through the opening in the insulating cover 68 and provides a fairly deep elongated vent orifice for the valve. A resilient ball 74 is force-fitted or pressed into the elongated stem or sleeve portion 73 and is compressed and deformed into an elongated configuration as shown, sealing off the vent orifice under a high sealing pressure in the same manner as previously described. Positioned inside the metallic cup 71 is a vent washer 75 having its opening 76 located in alignment with the opening of the central stem or sleeve portion 73. In this embodiment of the invention, the opening 76 in the vent washer 75 may be used as a means for increasing the initial first mode venting pressure at which the resilient ball 74 will be expelled from the vent orifice. Thus, the opening 76 in the vent washer 75 may be made of a size slightly smaller in diameter than the internal diameter of the central stem or sleeve portion 73 so as to restrict the outward movement of the resilient ball 74 upon the build-up of an abnormally high internal gas pressure inside the cell.

Once the resilient ball 74 has been expelled from within the vent orifice and through the opening 76 in the vent washer 75, the ball 74 is maintained in position overlying the opening 76 and is compressed and deformed into a flattened configuration as shown in phantom lines in Figure 7 by means of a metallic cap 77. The cap 77 is held tightly in place by the lower peripheral edges of the inverted metallic cup 71 which are crimped over the outer edges of the cap 77. A conductor member 78 is secured as by welding to the stem or sleeve portion 73 of the metallic cup 71 and makes electrical connection with one electrode of the cell. A

resilient spring member 79 which may be punched out from the cap 77 is positioned in contact with the metallic bottom cover plate 70 which serves as the negative terminal of the cell.

An important feature of the pressure relief vent valve of the invention is that the valve is resealable once the internal gas pressure which develops inside the cell has been relieved. This, it will be seen that in all of the embodiments of the vent valve described the resilient flattened ball of elastomeric material possesses an inherent resilient stress which acts as a biasing force to restore the ball back into its sealing position against the peripheral edge portions of the vent orifice when the ball is caused to undergo further temporary deformation upon the build-up of a predetermined internal gas pressure inside the cell. It should be noted, however, that in the case of miniature size cells such as AAA cells, the primary function of the valve is to act as a positive "fail-safe" pressure relief vent and once the ball has been expelled from the vent orifice, the valve must not plug up and fail to vent. In order to insure that the vent valve will operate safely in these miniature size cells, it may be desirable to assemble the vent valve in such a way that the resilient ball is under a fairly low final compression and, therefore, will vent at relatively low venting pressures. In such instances, the resilient ball may be prevented from seating properly with the vent orifice to achieve resealability due to the presence of particles of active material which may be carried up onto the valve seat from inside the cell. The failure of the valve to seal or reseat properly is not viewed as a fault of the valve but rather as simply a result of the environment.

In the broadest aspect of the invention, the resilient ball used in the pressure relief vent valve may be made from almost any resilient elastomeric material. Preferably, however, in the case of an alkaline galvanic cell, the resilient ball should be made from resilient elastomeric material which is chemically resistant to the alkaline electrolyte of the cell. A suitable chemically resistant elastomeric material for the resilient ball is an ethylene-propylene copolymer. The hardness of the resilient ball preferably is in the range of from about 60 to 70 Durometer and the ball should be capable of maintaining its resiliency over a long period of time under a substantial amount of deformation; for example, in the first mode of operation of the valve, the diameter of the elongated or cylindro-spherical ball force-fitted or pressed into the vent orifice should be about 50 to 70 per cent of the diameter of the ball in its initial spherical shape.

As already indicated, the peripheral edge

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portions surrounding the opening of the vent orifice may be used to form the valve seat for the resilient ball in the pressure relief vent valve of the invention. It should be understood, however, that the valve seat for the resilient ball may be formed by a separate member overlying the opening of the vent orifice as in the case of the vent washer used in the embodiment illustrated in Figure 7. Generally speaking, the valve seat in all the embodiments except that illustrated in Figure 6, should be roughly 90 degrees in cross-section forming a square shoulder with a sharp edge for minimal contact with the resilient ball to insure a fluid-tight seal.

It should be noted that the resilient ball used in the pressure relief vent valve is of an initial spherical shape and that the valve seat against which the ball bears is circular in the case where the valve is used only as a low pressure vent or in the case of the "two-mode" version of the valve. However, when the valve is used only in the first mode of operation as a positive "fail safe" pressure vent as described above in connection with miniature size cells, the resilient ball may be of other configurations such as spheroid, for example, although a spherical ball is preferred.

In some cases, it may be desirable to use a surface additive for lubricating the resilient ball in order to facilitate pressing the ball into the vent orifice and to insure that the ball is properly expelled from the vent orifice in the "two-mode" version of the valve. The lubricant also serves to seal minor imperfections in the valve seat or surfaces of the ball and prevents salt encrustment from any liquid electrolyte which may come into contact with the vent valve. Suitable surface additives and lubricants include silicone grease, soap and waxes, for example.

As an illustration of the practice of the invention, a number of alkaline zinc-manganese dioxide cells of various sizes, e.g., D, AA, AAA cells, have been made using the pressure relief vent valve of the invention. The resilient deformable ball used in the valves was of spherical shape and was made from an ethylene-propylene copolymer. The diameter of the balls ranged from about 3/32 to 3/16 inch depending on the size of the cell. The venting pressure level of the vent valves used in these cells was set by suitable choice of parameters, i.e., resiliency of the ball, the difference in relative sizes between the ball and the vent orifice, etc., over a wide range of sealing pressures from about 5 to 500 psi. The pressure relief vent valves were found to perform satisfactorily in that gas venting occurred in a predictable and reproducible

manner for the various venting pressures used.

It will be seen then that the present invention provides a novel and improved pressure relief vent valve for relieving high internal gas pressures from inside a fluid-tight sealed container and especially in alkaline galvanic cell. The pressure relief vent valve of the invention is particularly advantageous in that it is simple and compact and readily adaptable to use in miniature size cells, employs a minimum number of parts with the resilient ball being the only moving part, can be assembled as a unit with little or no handling and employs no parts having critical tolerances in its assembly. The vent valve is furthermore resealable once the internal gas pressure has been relieved from the inside of the container and is responsive over a wide range of gas pressures and is relatively inexpensive to manufacture. In view of the provisions of Section 9 of the Patent Act, attention is directed to our copending Specification 22263/73. (Serial No 1336568).

WHAT WE CLAIM IS:—

1. A pressure relief vent valve for releasing gas from inside a fluid tight container, which comprises a resilient deformable ball of an elastomeric material force-fitted into a smaller size vent orifice provided within a portion of said container, said ball being compressed and deformed into a substantially elongated configuration within said vent orifice such that the resilient stress of said ball exerts a high sealing force against the side walls of said orifice, said ball being expelled from said vent orifice upon the build-up of an abnormally high internal gas pressure inside said container.

2. A valve as claimed in claim 1 wherein the resilient deformable ball is made of an elastomeric material possessing a hardness of from 60 to 70 Durometer.

3. An alkaline galvanic cell having a valve as claimed in claim 1 or 2.

4. A cell as claimed in claim 3 further including a valve seat provided around the peripheral edge portions of said vent orifice and a retainer means positioned over and spaced from said valve seat such that the gap between said retainer means and said valve seat is smaller than the size of the resilient ball in its initial shape prior to being force-fitted into said vent orifice, said ball upon expulsion from said vent orifice being compressed and deformed by said retainer means into a substantially flattened configuration overlying said vent orifice and in contact with said valve seat forming a fluid-tight seal between said ball and said valve seat.

5. A cell as claimed in claim 3 or 4



portions surrounding the opening of the vent orifice may be used to form the valve seat for the resilient ball in the pressure relief vent valve of the invention. It should be understood, however, that the valve seat for the resilient ball may be formed by a separate member overlying the opening of the vent orifice as in the case of the vent washer used in the embodiment illustrated in Figure 7. Generally speaking, the valve seat in all the embodiments except that illustrated in Figure 6, should be roughly 90 degrees in cross-section forming a square shoulder with a sharp edge for minimal contact with the resilient ball to insure a fluid-tight seal.

It should be noted that the resilient ball used in the pressure relief vent valve is of an initial spherical shape and that the valve seat against which the ball bears is circular in the case where the valve is used only as a low pressure vent or in the case of the "two-mode" version of the valve. However, when the valve is used only in the first mode of operation as a positive "fail safe" pressure vent as described above in connection with miniature size cells, the resilient ball may be of other configurations such as spheroid, for example, although a spherical ball is preferred.

In some cases, it may be desirable to use a surface additive for lubricating the resilient ball in order to facilitate pressing the ball into the vent orifice and to insure that the ball is properly expelled from the vent orifice in the "two-mode" version of the valve. The lubricant also serves to seal minor imperfections in the valve seat or surfaces of the ball and prevents salt encrustment from any liquid electrolyte which may come into contact with the vent valve. Suitable surface additives and lubricants include silicone grease, soap and waxes, for example.

As an illustration of the practice of the invention, a number of alkaline zinc-manganese dioxide cells of various sizes, e.g., D, AA, AAA cells, have been made using the pressure relief vent valve of the invention. The resilient deformable ball used in the valves was of spherical shape and was made from an ethylene-propylene copolymer. The diameter of the balls ranged from about 3/32 to 3/16 inch depending on the size of the cell. The venting pressure level of the vent valves used in these cells was set by suitable choice of parameters, i.e., resiliency of the ball, the difference in relative sizes between the ball and the vent orifice, etc., over a wide range of sealing pressures from about 5 to 500 psi. The pressure relief vent valves were found to perform satisfactorily in that gas venting occurred in a predictable and reproducible

manner for the various venting pressures used.

It will be seen then that the present invention provides a novel and improved pressure relief vent valve for relieving high internal gas pressures from inside a fluid-tight sealed container and especially in alkaline galvanic cell. The pressure relief vent valve of the invention is particularly advantageous in that it is simple and compact and readily adaptable to use in miniature size cells, employs a minimum number of parts with the resilient ball being the only moving part, can be assembled as a unit with little or no handling and employs no parts having critical tolerances in its assembly. The vent valve is furthermore resealable once the internal gas pressure has been relieved from the inside of the container and is responsive over a wide range of gas pressures and is relatively inexpensive to manufacture. In view of the provisions of Section 9 of the Patent Act, attention is directed to our copending Specification 22263/73. (Serial No 1336568).

WHAT WE CLAIM IS:—

1. A pressure relief vent valve for releasing gas from inside a fluid tight container, which comprises a resilient deformable ball of an elastomeric material force-fitted into a smaller size vent orifice provided within a portion of said container, said ball being compressed and deformed into a substantially elongated configuration within said vent orifice such that the resilient stress of said ball exerts a high sealing force against the side walls of said orifice, said ball being expelled from said vent orifice upon the build-up of an abnormally high internal gas pressure inside said container.

2. A valve as claimed in claim 1 wherein the resilient deformable ball is made of an elastomeric material possessing a hardness of from 60 to 70 Durometer.

3. An alkaline galvanic cell having a valve as claimed in claim 1 or 2.

4. A cell as claimed in claim 3 further including a valve seat provided around the peripheral edge portions of said vent orifice and a retainer means positioned over and spaced from said valve seat such that the gap between said retainer means and said valve seat is smaller than the size of the resilient ball in its initial shape prior to being force-fitted into said vent orifice, said ball upon expulsion from said vent orifice being compressed and deformed by said retainer means into a substantially flattened configuration overlying said vent orifice and in contact with said valve seat forming a fluid-tight seal between said ball and said valve seat.

5. A cell as claimed in claim 3 or 4

wherein the vent orifice is provided within the closed end wall of said container and wherein the retainer means comprises a metallic cover plate having a central protuberance positioned over said closed end wall of said container and spaced from said valve seat, the gap between said valve seat and said central protuberance being smaller than the size of said resilient ball in its initial shape prior to being force-fitted into said vent orifice.

6. A cell as claimed in claim 4 wherein one end of said container is sealed by a closure comprising a rigid metallic cover which fits in said end of said container and an annular seal gasket fluid-tightly sealed between said metallic cover and said container, said metallic cover being formed with a centrally located depending stem portion which fits through the opening in said seal gasket, and wherein the vent orifice is provided through said centrally located depending stem portion of said metallic cover.

7. A cell as claimed in claim 6 wherein the retainer means comprises a metallic terminal cap positioned over and secured to said metallic cover, said terminal cap being spaced from the valve seat formed around the peripheral edge portions of said vent orifice such that the gap between said terminal cap and said valve seat is smaller than the size of the resilient ball in its initial shape prior to being force-fitted into said vent orifice.

8. A cell as claimed in claim 4 wherein one end of said container is sealed by a closure comprising a generally U-shaped annular seal gasket which fits in said end of said container, a rigid metallic cover positioned within said U-shaped seal gasket and a terminal rivet fitted through the central opening of said seal gasket, said seal gasket being fluid-tightly sealed between said metallic cover and said rivet and between said metallic cover and said container, and wherein the vent orifice is provided through said terminal rivet.

9. A cell as claimed in claim 8 wherein the rivet head portion of said terminal rivet is formed with a circular recess communicating with said vent orifice, the depth of said circular recess being smaller than the size of the resilient ball in its initial shape prior to being force-fitted into said vent orifice, and wherein said retainer means comprises a resilient spring member

overlying said circular recess and making electrical contact with a metallic cover plate locked in engagement around the outer extremities of the cell.

10. A cell as claimed in claim 4 wherein one end of the container is sealed by a closure comprising a rigid insulating annular cover which fits in said end of said container, the outer peripheral edges of said insulating annular cover abutting with the peripheral edges of said container forming a fluid-tight seal, said insulating annular cover having a shallow recess formed therein to accommodate a metallic cup having a centrally located depending stem portion fitting through the opening in said insulating annular cover, said depending stem portion forming the vent orifice and wherein a vent washer is positioned within said metallic cup having its opening in alignment with the opening of the depending stem portion and forming the valve seat.

11. A cell as claimed in claim 10 wherein the retainer means comprises a metallic cap positioned over said resilient ball in pressure contact therewith, said cap being spaced from the valve seat formed by the opening in said vent washer such the gap between said metallic cup and said valve seat is smaller than the size of the resilient ball in its initial shape prior to being force-fitted into said vent orifice.

12. A cell as claimed in claim 11 wherein a resilient spring member is positioned in contact between said metallic cap and a metallic closure plate locked in engagement around the outer extremities of said cell.

13. A cell as claimed in claim 11 wherein the opening in said vent washer is of a smaller size than the vent orifice formed by the centrally located depending stem portion of said metallic cup.

14. A pressure relief vent valve substantially as hereinbefore described with reference to and as illustrated in any one of the Figures of the accompanying drawings.

15. An alkaline galvanic cell substantially as hereinbefore described with reference to and as illustrated in any one of the Figures of the accompanying drawings.

16. A cell as claimed in any one of claims 3 to 13 or 15 wherein said deformable ball overlies said vent orifice.

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