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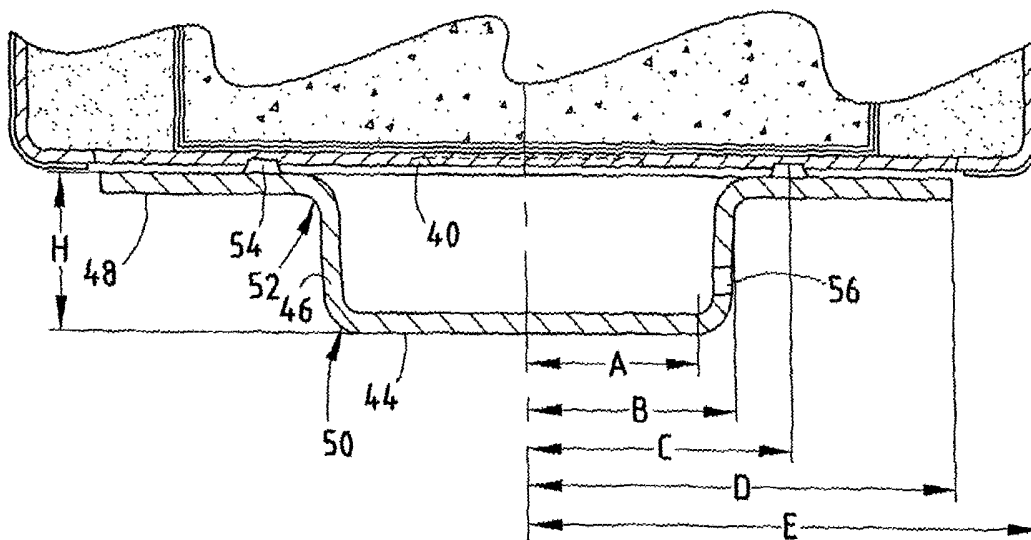
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(54) Title: ELECTROCHEMICAL CELL HAVING CAN VENT AND COVER TERMINAL



(57) Abstract: An electrochemical cell has a can having a first end, a second end, a side wall extending between the first and second ends, and an end wall extending across the first end. Positive and negative electrodes and an electrolyte are disposed in the can. A pressure relief mechanism is formed in the end wall of the can for releasing internal pressure from within the container when the internal pressure becomes excessive. A terminal cover is positioned on the end wall of the can to be in electrical contact therewith and extends over the pressure relief mechanism. The cover includes a protruding nubbin, a peripheral flange, and upstanding wall between the nubbin and flange. The cover is engaged with the end wall of the can at a location near the upstanding wall of the nubbin.



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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ELECTROCHEMICAL CELL HAVING CAN VENT AND COVER TERMINAL

The present invention generally relates to electrochemical cells, i.e., batteries, and, more particularly, to a primary alkaline zinc/manganese dioxide electrochemical cell having a pressure relief mechanism formed in the cell can for venting when exposed to excessive
5 pressure.

Conventional alkaline electrochemical cells generally include a cylindrical steel can having a closed bottom end, an open top end, and a cylindrical side wall extending between the top and bottom ends. Contained within the can is a positive electrode, referred to as the cathode, which typically comprises manganese dioxide as the active material. Also
10 contained within the can is a negative electrode, referred to as the anode, which typically comprises zinc as the active material. In bobbin-type cell constructions, the cathode is typically formed against the interior surface of the steel can, while the anode is generally centrally disposed in the can. In jellyroll-type cell constructions, the anode and cathode are spirally wound. A separator is located between the anode and the cathode, and an alkaline
15 electrolyte solution simultaneously contacts the anode, the cathode, and the separator. A conductive current collector is commonly inserted into the anode active material, and a collector and seal assembly, which typically includes an annular polymeric seal, an inner metal cover, a current collector, and an outer cover, provides closure to the open top end of the steel can to seal the active electrochemical materials in the sealed volume of the can.

Cylindrical alkaline electrochemical cells are commonly sealed closed by placing the annular polymeric (e.g., nylon) seal in the open end of the steel can and crimping the upper end of the can radially inwardly and over the outer periphery of the seal to compress the seal against the can. However, electrochemical cells commonly employ electrochemically active materials, such as zinc, which generate hydrogen gas and other gases during storage and
20 sometimes during or following service use. With the cell can sealed closed, excessive build-up of high pressure gases within the sealed can may cause damage to the cell and/or the device in which the cell is employed. Thus, it is desirable to provide a controlled vent mechanism that vents highly pressurized gases from within the can to prevent the pressurized gases from reaching extreme levels that may cause the can to uncrimp and release electrolyte
25 solution and particulate matter.

One widely acceptable approach to venting excessive pressurized gases has included the use of a vent formed in the annular polymeric seal of the collector and seal assembly,

which is intended to rupture upon experiencing an excessive pressure build-up within the sealed volume of the cell. For example, U.S. Patent No. 5,667,912 discloses a current collector assembly having a seal with a thinned portion which is intended to shear when the internal pressure exceeds a predetermined pressure limit. Conventional ventable seals of this type typically employ a circular thinned region formed in the annular polymeric seal. However, the amount of space generally occupied by the annular seal and the corresponding current collector, inner metal cover, and outer cover, is significant. The greater the space occupied by the seal and collector assembly, the less space that there is available within the cell for the electrochemically active materials. Consequently, a reduction in the amount of electrochemically active materials provided within the cell generally results in a shorter service life for the cell. It is therefore desirable to maximize the internal volume within the electrochemical cell that is available for the electrochemically active components.

In order to minimize the space occupied by the collector and seal assembly, it has been proposed to form the pressure release mechanism in the closed bottom end of the cell can such that it is covered by the positive contact terminal, as disclosed in International Patent Publication No. WO 99/18667, published 16 August 1999, and U.S. Patent No. 6,346,342, issued 12 February 2002. According to this proposed approach, the positive contact terminal includes an outwardly protruding nubbin having an upstanding wall extending from a peripheral flange that is welded to the closed bottom end of the cell can. Typically, a jacket (e.g., label) is formed around the outer cylindrical wall of the can and extends over the peripheral edge of the peripheral flange of the positive contact terminal. While this approach generally reduces the amount of volume that is otherwise necessary for the collector and seal assembly, and therefore enhances the amount of usable sealed volume within the cell, a number of shortcomings may be present. It is possible that when the pressure relief mechanism vents the positive contact terminal may become separated from the closed bottom end of the can. In addition, undesirably large variability may exist in the range of vent pressures, which may result in unexpectedly high vent pressures. This may be due, at least partially, to the cover being welded to the can at a location such that the cover restricts bulging of the bottom end of the can. In addition, the jacket, which is typically shrink-wrapped onto the outer surface of the can, may also restrict the bulging of the bottom end of the can. As a consequence, high variability in the vent pressure and cover separation from the cell may occur.

Accordingly, it is therefore desirable to provide for an electrochemical cell having a vent formed in the closed end of the can with a cover such that the cell is able to consistently vent pressurized gases, and further which is not susceptible to separation between the cover and the can.

5 The present invention improves the protective safeguards of an electrochemical cell with an enhanced pressure relief mechanism formed in the closed end of a cell container that allows for the use of a low profile seal assembly. To achieve this and other advantages, and in accordance with the purpose of the invention as embodied and described herein, the present invention provides for an electrochemical cell comprising a container having a first
10 end, a second end, a side wall extending between the first and second ends, and an end wall extending across the first end. The cell also includes a positive electrode comprising manganese dioxide, a negative electrode comprising zinc, and an alkaline electrolyte, all disposed in the container. A pressure relief mechanism is formed in the end wall of the container for releasing internal pressure from within the container when the internal pressure
15 becomes excessive. A terminal cover is positioned on the end wall of the container to be in electrical contact therewith and extends over the pressure relief mechanism. The terminal cover has a peripheral flange with a peripheral edge and a protruding nubbin, the nubbin having a contact surface and an upstanding wall between the contact surface and the peripheral flange. The exterior of the upstanding wall of the nubbin is a radial distance B,
20 and the exterior surface of the container side wall is at a radial distance E, from the central longitudinal axis of the cell. The terminal cover is engaged with the end wall of the container at a location having a radial midpoint at a radial distance C from the central longitudinal axis of the cell, such that the difference $C - B$ is equal to or less than the difference $E - C$ when E is greater than or equal to 4.3 mm, and 1.5 times $C - B$ is equal to or
25 less than $E - C$ when E is less than 4.3 mm. In this way, the location of engagement of the cover with the end wall of the can is near the upstanding wall of the nubbin.

The present invention is further illustrated by reference to the drawings, in which:

Fig. 1 is a longitudinal cross-sectional view of an electrochemical cell having a pressure relief mechanism and contact terminal cover provided on the closed bottom end of a
30 can according to the present invention;

Fig. 2 is an enlarged cross-sectional view of the bottom portion of the electrochemical cell shown in Fig. 1;

Fig. 3 is an exploded perspective view of the bottom end of the cell illustrating the cover separated from the closed end wall of the can;

Fig. 4 is a perspective view of the bottom end of the electrochemical cell;

Fig. 5 is an enlarged cross-sectional view of the bottom portion of the electrochemical cell shown in Fig. 1 during a venting condition; and

Fig. 6 is a cross-sectional view of the bottom portion of an electrochemical cell having a contact terminal cover according to another embodiment.

Referring to Fig. 1, a cylindrical alkaline electrochemical cell 10 according to an embodiment of the present invention is shown having a stress concentration pressure relief mechanism formed in the closed bottom end of the cell can and an outer terminal cover attached to the can bottom end. Electrochemical cell 10 includes a cylindrical steel can 12 having a bottom end 14 closed with an end wall, an open top end 16, and a cylindrical side wall extending between the top and bottom ends. The closed bottom end 14 of steel can 12 has a positive terminal cover 42 welded or otherwise attached thereto and formed of plated steel, with a protruding nubbin (i.e., protrusion) 44 at its center region, which forms the positive contact terminal of cell 10. Assembled to the open top end 16 of steel can 12 is a conductive (e.g., metal) closing cover 30 which forms the negative contact terminal of cell 10. A jacket 20 is formed about the exterior surface of steel can 12, and is formed over the peripheral edge of the closed bottom end 14 of the can 12. The jacket 20 preferably does not extend over the peripheral edge of the positive contact terminal 42. The jacket 20 may be an adhesive label such as a metalized, plastic film label.

A cathode 22 is formed about the interior surface of steel can 12. Cathode 22 may be formed of a mixture of manganese dioxide, graphite, potassium hydroxide (KOH) solution, and additives, according to one example. A separator 24, which may be formed of a non-woven fabric that prevents migration of any solid particles in the cell, is disposed about the interior surface of cathode 22. An anode 26 is disposed with an electrolyte inside the separator 24 and in contact with a current collector 28 which may include a brass nail having an elongated body and an enlarged head at one end. The anode 26 may be formed of zinc powder, a gelling agent, and additives, according to one example. Accordingly, the cathode 22 is configured as the positive electrode, and the anode 26 is configured as the negative electrode. While a bobbin-type cell construction is shown and described herein, it should be

appreciated that the electrochemical cell 10 can otherwise be configured, such as a jellyroll cell construction.

The current collector 28 contacts the outer closing cover 30, which forms the negative contact terminal of cell 10. The negative cover 30 is preferably formed of plated steel, and may be held in contact with the current collector 28 via weld 34 or pressure contact. A ring-shaped polymeric (e.g., nylon) seal 32 having a generally J-shaped cross section is disposed in the open end of steel can 12 to provide a sealed closure between the can 12 and negative cover 30 to prevent leakage of electrochemically active cell materials contained in the steel can 12. The assembly of the seal 32 may include disposing the seal 32 in the open end 16 of steel can 12 on top of a bead 36 formed radially inward on the side wall of can 12, or alternately in a flared opening of can 12, and crimping the upper end of can 12 inwardly and over the outer periphery of the seal 32 and negative cover 30 to compress seal 32 against bead 36. Therefore, the polymeric seal 32 is compressed between the peripheral edge of negative cover 30 and the upper end wall of steel can 12. It should be appreciated that the negative cover 30 is therefore electrically insulated from the steel can 12 by way of polymeric seal 32.

In an embodiment of the present invention, a stress concentration pressure relief mechanism 40 is formed in the closed bottom end 14 of steel can 12, and a positive cover 42, serving as the positive contact terminal, is connected to the bottom end wall 14 of steel can 12 so as to cover the pressure relief mechanism 40. The stress concentrator 40 may include a reduced thickness groove that has a thinned section which acts as a pressure relief mechanism for venting pressurized gases when exposed to an excessive pressure differential.

The stress concentrator 40 is designed to fracture along the reduced thickness groove, which is shown herein as a generally C-shaped groove extending angularly in the shape of a circle for approximately three hundred degrees (300°), with a non-reduced section extending through an angular rotation of approximately sixty degrees (60°) so as to serve as a hinge.

The stress concentration pressure relief mechanism 40 is positioned under the positive cover 42 so as to prevent electrochemical materials from spraying directly outward from the cell 10 upon rupture. To allow for release of vented gases to the outside atmosphere, the positive cover 42 has one or more openings 56 formed in the upstanding wall 46 forming the protruding nubbin 44. Also, if the cell 10 is contacted in series with another cell such that the end of the positive cover 42 of the cell 10 is pressed against the

terminal of another cell, the provision of the positive cover 42 over pressure relief mechanism 40 allows mechanism 40 to bow outwardly under the positive protrusion 44 and ultimately rupture. If the positive cover 42 was not present during such circumstances, contact between the two contacting cells may otherwise prevent the pressure relief mechanism 40 from rupturing. Further, if no positive cover 42 were provided over pressure relief mechanism 40, the pressure relief mechanism 40 at the closed end 14 of cell 10 would be more susceptible to damage. Positive cover 42 also shields pressure relief mechanism 40 from the corrosive effects of the ambient environment and therefore reduces the possibility of premature venting and/or leakage. Thus, by forming the pressure relief mechanism 40 under the positive cover 42, problems associated with prior art constructions are overcome, and thus a commercially feasible pressure relief mechanism for a cell is realized.

Due to the formation of a pressure relief mechanism 40 in the bottom end 14 of the cell can 12, the need for a complex and voluminous collector and seal assembly is thereby eliminated, and instead the open end 16 of can 12 may be sealed using seal construction techniques that were not previously feasible in commercial cells due to the need to allow gases to escape through the pressure relief mechanism 40 to the exterior of the cell 10. The example shown of the collector and seal assembly having a seal 32 with a J-shaped cross section and negative cover 30 is only one example of a low profile collector and seal assembly that may be employed on a cell having the pressure relief mechanism 40 and cover 42 of the present invention, as other seal assemblies may be employed.

Referring to Figs. 2 and 3, the positive contact terminal (cover) 42 is shown in greater detail covering the stress concentration pressure relief mechanism 40. The stress concentration pressure relief mechanism 40 is provided by forming a groove in either the outer surface (as shown) and/or the inner surface of the bottom end wall 14 of steel can 12. The stress concentration groove 40 may be formed by punching a depressed groove in the bottom end 14 of steel can 12, such as by a press punching process, to reconfigure the bottom end 14 of steel can 12. While the stress concentrator 40 includes a C-shaped groove in the embodiment shown in Fig. 3, it should be appreciated that any one or more C-shaped or alternately configured stress concentration pressure relief grooves may be employed.

The size of the area generally circumscribed by the C-shaped groove 40 is preferably selected such that upon rupture due to excessive internal pressure within the cell 10, an area defined by the stress concentration groove 40 may pivot at a hinge and open within the

positive protrusion 44 of the positive cover 42 without interference from the positive cover 42, and without damaging the welds 54 attaching the positive cover 42 to the bottom end wall 14 of can 12. In general, the size of the area defined by the groove 40, as well as the selected depth of the groove, depends upon the diameter of the can 12 and the pressure at which the pressure relief mechanism 40 is intended to rupture to release internally-generated gases. The preferred venting pressure varies depending on the size of the electrochemical cell.

The stress concentration groove 40 provides a reduced thickness in the steel can 12 sufficient to shear and thereby fracture upon experiencing a predetermined pressure differential. Accordingly, the groove 40 extends to a depth equal to the difference of the can thickness minus the groove thickness. The cross section of the groove 40 may be configured as a truncated V-shaped (i.e., wedge-shaped) groove having a flat bottom surface in place of the truncated apex of the V-shaped groove, and may be formed at an angle in the range of about ten degrees (10°) to one hundred degrees (100°).

Referring particularly to Fig. 2, the positive contact terminal 42 is shown with the protruding nubbin 44 having a substantially flat outer contact surface in a generally circular configuration having a radius A. Radius A is measured from and normal to the central longitudinal axis of the cell, about which the positive contact terminal 42 is centered, to a point where the flat contact surface transitions towards the vertical upstanding wall. The positive contact terminal 42 also includes a peripheral flange 48 which lays substantially near, and could set flat up against, the bottom end 14 of steel can 12. Formed between the peripheral flange 48 and the flat contact surface of nubbin 44 is a substantially vertical upstanding wall 46 which may have an elevated rise angle of approximately one to five degrees, according to one embodiment. The upstanding wall 46 is formed about a circle having a radius B. Radius B is measured from and normal to the central longitudinal axis of the cell to the outer surface of the upstanding wall 46 at a location at the middle of the height H of positive contact terminal 42, where the height H is the overall height of the cover, excluding any weld projections. The upstanding wall 46 transitions into the peripheral flange 48 at a corner 52. The opposite end of upstanding wall 46 transitions to the flat surface of nubbin 44 at a corner 50.

The positive contact terminal 42 is attached to the bottom surface of closed end 14 of steel can 12 via a plurality of welds 54, such as three equiangularly spaced welds 54 located

every one hundred twenty degrees (120°). The welds 54 may be formed at weld protrusions formed on the flange. Weld projections can vary in size depending on such factors as terminal and container compositions and thicknesses, as well as the welding process used, but projections of approximately 0.19 to 0.254 mm (0.0075 to 0.010 inches) from the surface of the flange are generally suitable for welding 0.254 mm (0.010 inches) thick nickel plated steel contact terminals to the bottoms of 0.254 mm (0.010 inches) thick nickel plated steel cans. While three welds 54 are shown for providing both a physical connection and an electrical path between the positive contact terminal 42 and the steel can 12, it should be appreciated that other bonding techniques such as a conductive adhesive, may alternately be employed.

According to the present invention, the bonding location, such as the location of welds 54, is located substantially near the upstanding wall 46, and more particularly is near transition corner 50 between the upstanding wall 46 and the flat surface of the nubbin 44. According to the embodiment shown in Fig. 2, the welds 54 are located a distance C from the center of the cell 10. The radius C is measured from and normal to the central longitudinal axis of the cell to the midpoint of the weld projection. The plurality of welds 54 is located close to the upstanding wall 46. The welds 54 may be located at the transition corner 52. Accordingly, the welds 54 are located more towards the central axis of the cell, as compared to prior positive terminal connections. By locating the welds 54 substantially near the vertical upstanding wall 46, the bottom end wall 14 of can 12 is able to bulge more freely with reduced restraint caused by the welds and the contact terminal flange, so the welds 54 are less susceptible to damage caused by bulging. For this reason, the ratio $(C - B) : (E - C)$ is small, and often the smaller this ratio the better. For example $(C - B) : (E - C)$ may advantageously be no greater than 0.50 : 1, no greater than 0.25 : 1, or no greater than 0.10 : 1.

The positive contact terminal 42 employs a peripheral flange 48 having an outer radius D. The radius D is measured from and normal to the central longitudinal axis of the cell to the outer peripheral edge of the peripheral flange 48. The peripheral flange 48 shown generally extends substantially planar from the transition corner 52 to the outer peripheral edge as shown; however, it should be appreciated that various other shapes may be provided in place of planar flange 48.

The steel can 12 has an outside radius E. The radius E is measured from and normal to the central longitudinal axis of the cell to the outer side wall of the steel can 12, at its widest point, excluding the jacket 20.

5 The radial distance from the center of weld 54 to the outer side wall of the upstanding wall 46 at a location midway of height H, is C - B. The radial distance from the center of the welds 54 to the outer side wall of the steel can 12 is E - C.

10 In general, in cells according to the present invention, the difference C - B is greater than or equal to the difference E - C. In other words, the center of the point of attachment of the positive contact terminal to the container is closer to the upstanding wall of the nubbin than to the side wall of the container. The larger the diameter of the cell, the more the container bottom will tend to bulge before activation of the pressure relief mechanism. As a result, the larger the cell diameter, the more desirable it is for the positive contact terminal to be engaged with the container bottom at a point closer to the upstanding wall of the nubbin. However, when the cell diameter is very small, i. e., less than 4.3 mm (1.70 inches), there is less bulging of the container bottom before the pressure relief mechanism activates, the radial width of the flange may be small, and the positive contact terminal may be attached to the container relatively closer to the side wall of the container. Therefore, for such very small diameter cells (e.g., IEC LR8D425 size), 1.5 times the difference C - B is equal to or less than the difference E - C.

20 It should be appreciated that by employing a reduced radius peripheral flange 48, the positive contact terminal 42 of the present invention is small enough that the jacket 20 does not interfere with the venting operation of the pressure relief mechanism 40. According to the embodiments shown, the jacket 20 extends onto a peripheral end portion of the bottom end 14 of the steel can 12, however, the jacket 20 does not extend onto and cover the peripheral flange 48 of the positive contact terminal 42. Instead, as illustrated in Fig. 4, the jacket 20 falls short of reaching the peripheral flange 48. While the jacket 20 preferably does not make contact with the peripheral flange 48, it should be appreciated that the jacket 20 may overlap and extend onto the peripheral flange 48 provided the jacket 20 does not interfere with the operation of the pressure relief mechanism 40. Alternatively, rather than reducing the diameter of the peripheral flange 48, the amount by which jacket 20 extends over the bottom end 14 of the steel can 12 may be reduced, or a combination of a smaller

diameter peripheral flange 48 and a shorter jacket 20 may be used, so that the jacket 20 does not contact the peripheral flange 48.

Accordingly, the stress concentration pressure relief mechanism 40 and positive contact terminal 42 of the present invention provides for a reliable vent mechanism for releasing high pressure gases during a venting occurrence of the cell 10. As seen in Fig. 5, the stress concentration groove 40 ruptures upon experiencing the predetermined pressure threshold, such that a portion of the end wall of steel can 12 is forced downward in the area generally enclosed by positive cover 42, and preferably remains connected at hinge 60. This allows for the escape of the pressurized gases from within the cell to the surrounding outside environment via the ruptured vent and openings 56. The stress concentrator groove 40 is formed in the steel can 12 which allows for the use of a low profile seal assembly for sealing the open end of the steel can 12, and results in significant reduction of bulging in the closed bottom end 14 of the steel can 12. In addition, the location of the welds 54 connecting the positive contact terminal 42 to the bottom end wall 14 of the can 12 is moved inward as close as possible so as to reduce the amount of stress that may otherwise adversely affect the venting pressure consistency. Further, the reduced size of the peripheral flange 48 of the positive contact terminal 42 reduces any interference with the venting operation that may otherwise be caused by the jacket 20 formed over the peripheral flange 48 of the cover 42. In addition, reduced size of the peripheral flange 48 further results in reduced material to form the cover 42, thereby resulting in a cost savings.

Referring to Fig. 6, a positive contact terminal cover 142 is shown welded on the closed bottom end of steel can for a different size battery according to a second embodiment of the present invention. The positive cover 142 likewise includes a peripheral flange 148 having a peripheral edge, and a protruding nubbin 144 having a substantially flat outer contact surface in a generally circular configuration. According to this embodiment, the positive cover 142 employs an angled upstanding wall 146 having an elevated rise angle of approximately twenty-one degrees, in contrast to the substantially vertical wall shown in the first embodiment. In addition, the positive cover 142 has a step 150 formed between the peripheral flange 148 and the upstanding wall 146. Accordingly, it should be appreciated that the positive cover 142 may employ a substantially vertical upstanding wall or a slightly angled wall, and may further employ one or more steps formed near or the peripheral flange, without departing from the teachings of the present invention.

EXAMPLE 1

LR6 cylindrical alkaline zinc/MnO₂ cells were made with pressure relief mechanisms formed in the can bottom. These cells were similar to cell 10 in Fig. 1, except that each had a conventional positive contact terminal (similar to that of the cell in Fig. 8A of WO 99/18667). This positive contact terminal had a peripheral flange with a large diameter (i.e., a large radius D as defined above) and weld projections located relatively close to the edge of the peripheral flange. The cell jacket also extended over the peripheral flange of the positive contact terminal. Nominal relationships for these cells are summarized in the Table below. Reference letters and numerals in the Table are as shown in Fig. 2.

The LR6 cells had steel cans 12 with a thickness of 0.254 mm (0.01 inches). For such cells it is generally preferred to vent pressurized gases that reach a pressure above about 400 psi (28.1 kg/cm²), relative to a normal atmospheric pressure, and more particularly to vent gases upon reaching a pressure above about 42.2 kg/cm² (600 psi). The maximum pressure at which gases should be vented is preferably about 126.5 kg/cm² (1800 psi), and more preferably no more than about 84.4 kg/cm² (1200 psi). The stress concentrator groove 40 had a metal thickness of approximately 0.0508 mm (0.002 inches). The predicted nominal venting pressure was approximately 70.3 kg/cm² (1,000 psi).

Cells were tested hydraulically to determine the pressure at which the pressure relief mechanism opened (referred to as the vent pressure). The average vent pressure was about 77.5 kg/cm² (1102 psi), with a standard deviation of about 8.30 kg/cm² (118 psi). The high average vent pressure and high variability resulted in unacceptably high predicted vent pressures for a portion of the total population of such cells. It was also observed that at least one of the three contact terminal welds was typically broken before each of the cells vented. This was undesirable because of the possibility of contact terminals breaking loose from the cells before or during cell venting.

Examination of the vented cells suggested that the contact terminals were affecting the vent pressures by interfering with the bulging of the can bottom, which is important to the proper operation of the pressure relief mechanism. Increasing the height of the weld projections, while reducing undesirable broken welds during testing, did not eliminate broken welds or prevent the contact terminal from interfering with can bulging and venting.

Examination suggested that the absence of holes as vent openings in the contact terminals might have affected the vent pressure. Additional testing confirmed that the

average vent pressure was reduced by almost 10%, and the incidence of broken welds was reduced, but vent pressure variability was still higher than desired when vent holes were provided through the upstanding wall of the nubbin.

Examination also suggested that the cell jackets were also adversely affecting vent pressures. This was confirmed by vent testing additional cells without jackets. The average vent pressure of theunjacketed cells was reduced by about 13.5 kg/cm^2 (192 psi), and the standard deviation was reduced by more than 60%.

EXAMPLE 2

LR6 cells similar to those in Example 1 were made according to the present invention, as described above and illustrated in Fig. 1. Nominal relationships are compared to the cells of Example 1 in the Table. Vent holes were provided through the contact terminal. The diameter of the positive contact terminal flange was reduced so the jacket did not extend over the flange. The weld projections were moved radially inward, close to the contact terminal nubbin. The height of the weld projections was also increased from 0.19 mm (0.0075 in.) to 0.25 mm (0.010 in.).

The average vent pressure for cells of Example 2 was about 62.6 kg/cm^2 (890 psi), with acceptable variability and a low incidence of weld breakage.

Accordingly, applying the above principles to Example 2, to reduce the effects of bulging of the can bottom on vent pressure, LR6 cells advantageously have one or more of the following features: a radius C that is no more than 3.556 mm (0.140 inches), and a ratio $(C - B) : (E - C)$ no more than 0.22 : 1. Similarly, to prevent the jacket from adversely affecting vent pressure, LR6 cells advantageously have a radius D that is no more than 5.842 mm (0.230 inches), and more advantageously no more than 5.715 mm (0.225 inches).

Table

Relationship	Example 1 mm (in.)	Example 2 mm (in.)
Radial distance to edge of flat contact surface (A)	2.286 (0.09)	2.286 (0.09)
Radius of corner 52	0.254 (0.01)	0.254 (0.01)
Radius of corner 50'	0.508 (0.02)	0.508 (0.02)
Radial distance to upstanding wall of nubbin (B)	2.819 (0.111)	2.819 (0.111)
Radial distance to center of weld projection (C)	5.588 (0.220)	3.556 (0.140)
Radial distance to edge of terminal flange (D)	6.604 (0.260)	5.715 (0.225)
Radial distance to exterior surface of container wall (E)	6.960 (0.274)	6.960 (0.274)
(C - B)	2.769 (0.109)	0.737 (0.029)
(E - C)	1.372 (0.054)	3.404 (0.134)
(D - C)	1.016 (0.040)	2.159 (0.085)

While the above Examples show LR6 cells, the present invention may be an alkaline zinc/MnO₂ cell of any size. It is particularly well suited for cylindrical cells whose external shapes and dimensions are defined in an industry standard. Examples include LR8D425 (maximum diameter 8.3 mm), LR1 (maximum diameter 12.0 mm), LR03 (maximum diameter 10.5 mm), LR6 (maximum diameter 14.5 mm), LR14 (maximum diameter 26.2 mm), and LR20 (maximum diameter 34.2 mm) cells, all of which are defined in IEC (International Electrochemical Commission) Publication 60086-2, Primary Batteries - Part 2: Physical and electrical specifications (2001). This standard places a dimensional limit on the diameter of nubbin 44 of positive contact terminal 42 as well as the outside diameter of the cell.

Other modifications may be made to the embodiments of the invention described above by one skilled in the art. For example, other suitable materials may be used, the compositions of the electrodes may be changed, and the arrangement of the contents of the cell may be varied. Other means of closing and sealing the open end of the cell container, and other pressure relief mechanism designs may be used.

It will be understood by those who practice the invention and those skilled in the art that various modifications and improvements may be made to the invention.

The invention may also be adapted to other cell types besides alkaline zinc/MnO₂ cells, and to other cell shapes, such as prismatic cells.

CLAIMS:

1. An electrochemical cell comprising:
 - a container having a first end, a second end, a side wall extending between the first and second ends, and an end wall extending across the first end;
 - 5 a positive electrode comprising manganese dioxide disposed in the container;
 - a negative electrode comprising zinc disposed in the container;
 - an aqueous alkaline electrolyte disposed in the container;
 - a pressure relief mechanism formed in the end wall of the container for releasing internal pressure from within the container; and
 - 10 a terminal cover positioned on the end wall of the container in electrical contact therewith and extending over the pressure relief mechanism, the terminal cover including a peripheral flange with a peripheral edge and a protruding nubbin, the nubbin having a contact surface and an upstanding wall between the contact surface and the peripheral flange;
 - 15 wherein the exterior surface of the upstanding wall is at a radial distance B, the cover is engaged with the end wall of the container at a location having a radial midpoint at a radial distance C, the exterior surface of the container side wall is at a radial distance E, radial distances B, C and E are measured from the central longitudinal axis of the cell, the difference $C - B$ is equal to or less than the difference $E - C$ when E is greater than or
 - 20 equal to 4.3 mm, and 1.5 times the difference $C - B$ is equal to or less than the difference $E - C$ when E is less than 4.3 mm.
2. An electrochemical cell according to claim 1, wherein a ratio $(C - B) : (E - C)$ is no greater than 0.50 : 1.
- 25 3. An electrochemical cell according to claim 2, wherein a ratio $(C - B) : (E - C)$ is no greater than 0.25 : 1.
4. An electrochemical cell according to claim 3, wherein a ratio $(C - B) : (E - C)$ is no greater than 0.10 : 1.
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5. An electrochemical cell according to any preceding claim further comprising a jacket applied to an exterior surface of the side wall of the container and extending partially over the end wall of the container; wherein the peripheral edge of the flange is disposed radially inward of the jacket.

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6. An electrochemical cell according to any preceding claim, wherein the peripheral edge of the flange is at a radial distance D from the central longitudinal axis of the cell and the difference C - B is equal to or less than the difference D - C.

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7. An electrochemical cell according to any preceding claim, wherein at least one vent opening is provided through the terminal cover.

8. An electrochemical cell according to any preceding claim, wherein the at least one vent opening is provided through the upstanding wall of the nubbin.

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9. An electrochemical cell according to any preceding claim, wherein the second end of the container comprises an open second end sealed closed with at least a closing cover and a collector and seal assembly.

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10. An electrochemical cell according to any preceding claim, wherein the pressure relief mechanism comprises a stress concentration groove.

11. An electrochemical cell according to any preceding claim, wherein the terminal cover is welded to the end wall of the container.

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12. An electrochemical cell according to any preceding claim, wherein one of the positive and negative electrodes is formed against an interior surface of the container, and the other of the positive and negative electrodes is disposed within a cavity formed therein.

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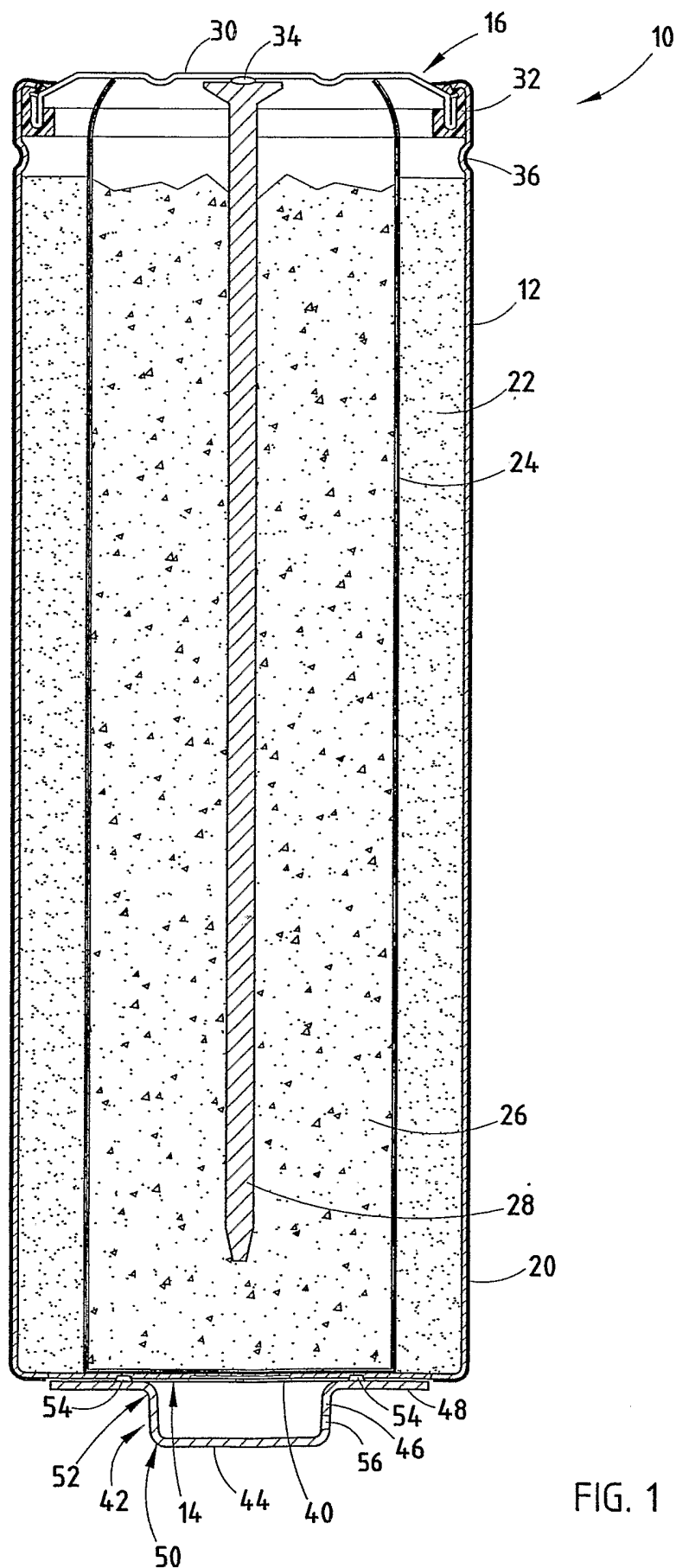
13. An electrochemical cell according to any preceding claim, wherein the terminal cover positioned on the end wall of the container comprises a positive contact terminal.

14. An electrochemical cell according to any preceding claim, wherein the cell is an LR6 size cell.

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15. An electrochemical cell according to claim 14, wherein the cover is connected to the end wall of the container at a location whose radial midpoint is no more than 3.556 mm from the center of the terminal cover. ·
- 5 16. An electrochemical cell according to claim 14 or claim 15, wherein the peripheral flange of the terminal cover has a maximum radius of 5.842 mm.
17. An electrochemical cell according to any of claims 14 to 16, wherein the peripheral flange has a radius of 5.715 mm.

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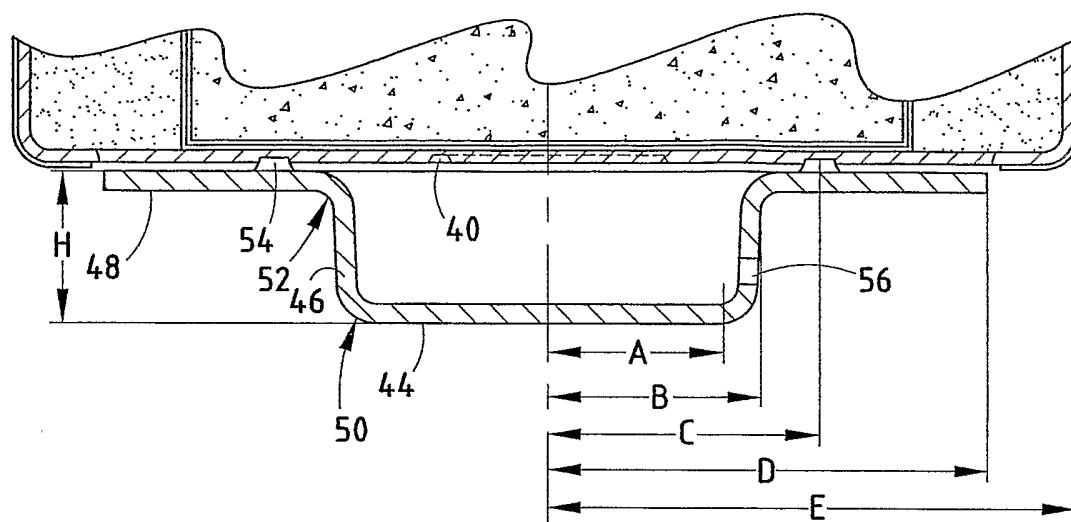


FIG. 2

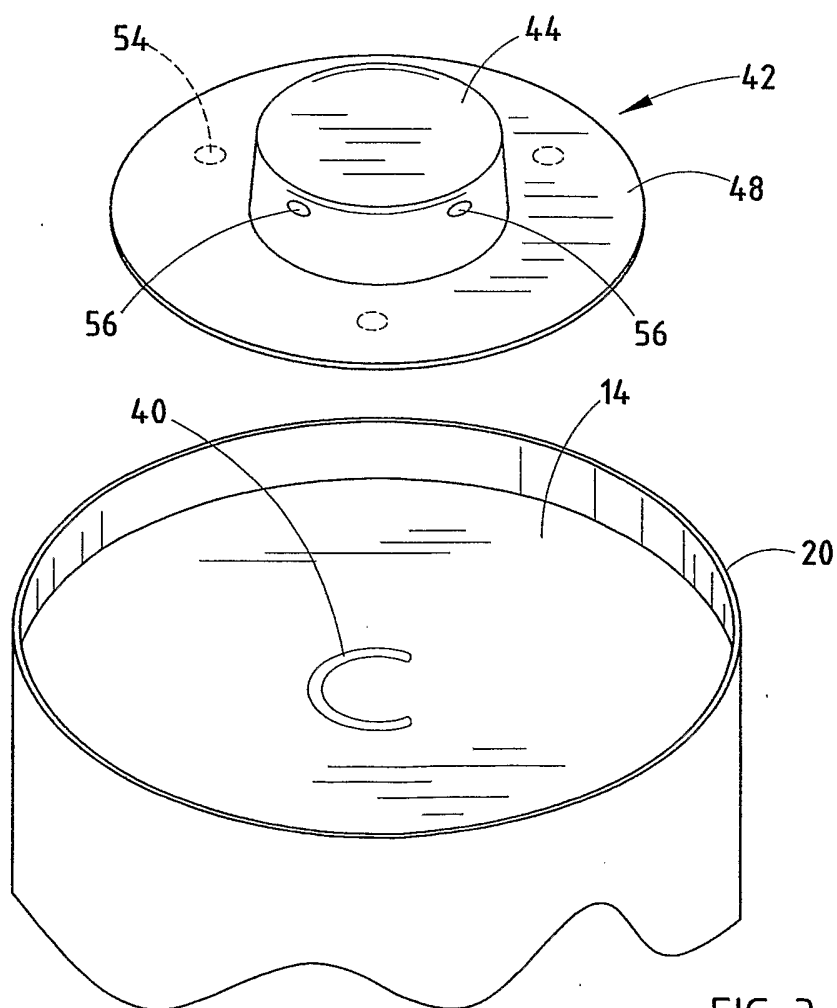
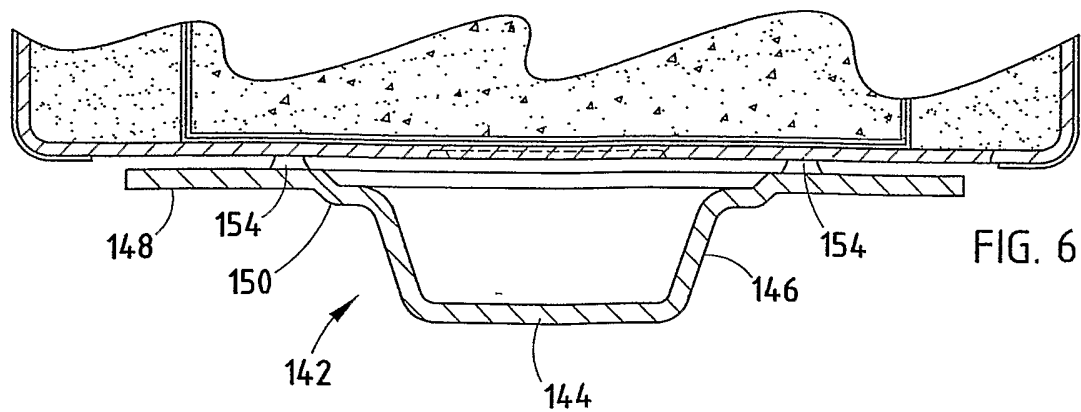
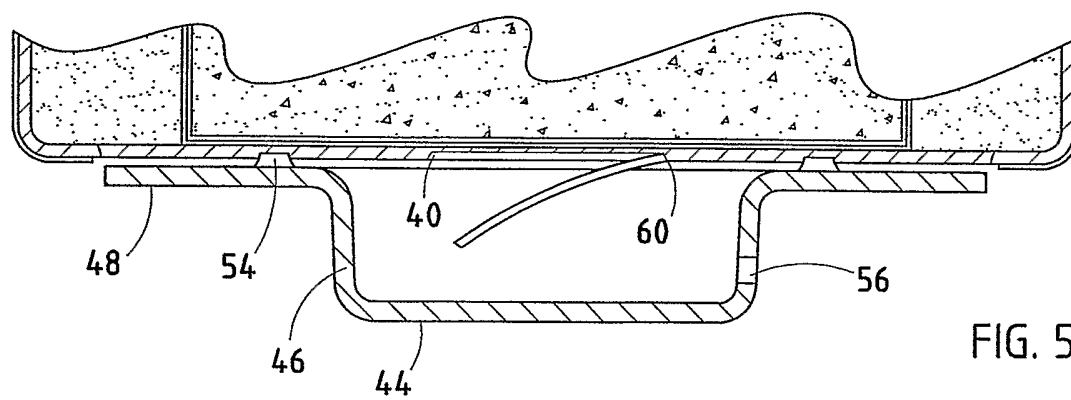
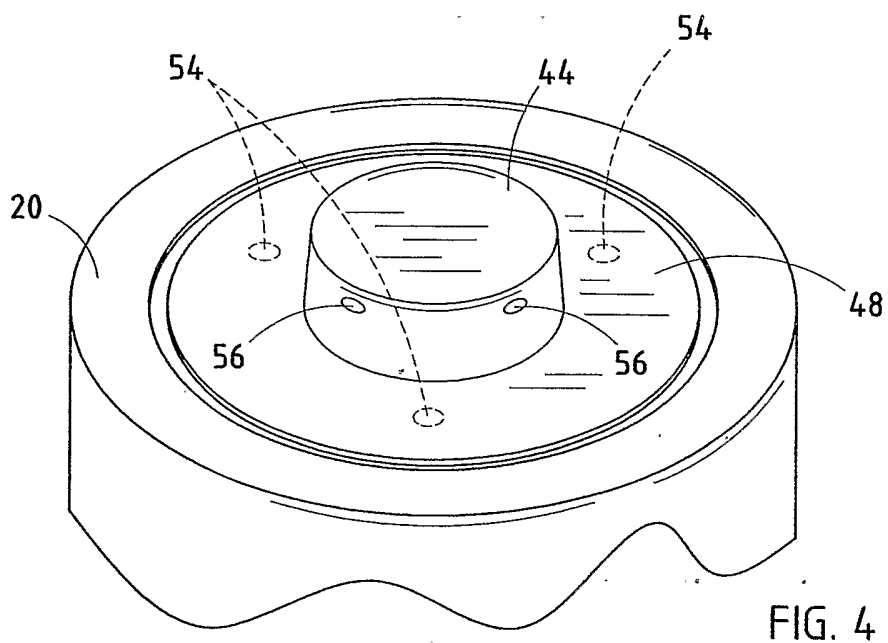


FIG. 3

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 02/24965

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H01M2/12 H01M2/04 H01M2/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 5 667 912 A (GEORGOPOULOS PHILIP, WESTLAKE, US) 16 September 1997 (1997-09-16) figure 4	1-17
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

13 November 2002

Date of mailing of the international search report

20/11/2002

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 02/24965

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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