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(54) **BATTERY SAFETY SYSTEMS, METHODS AND COMPOSITIONS**

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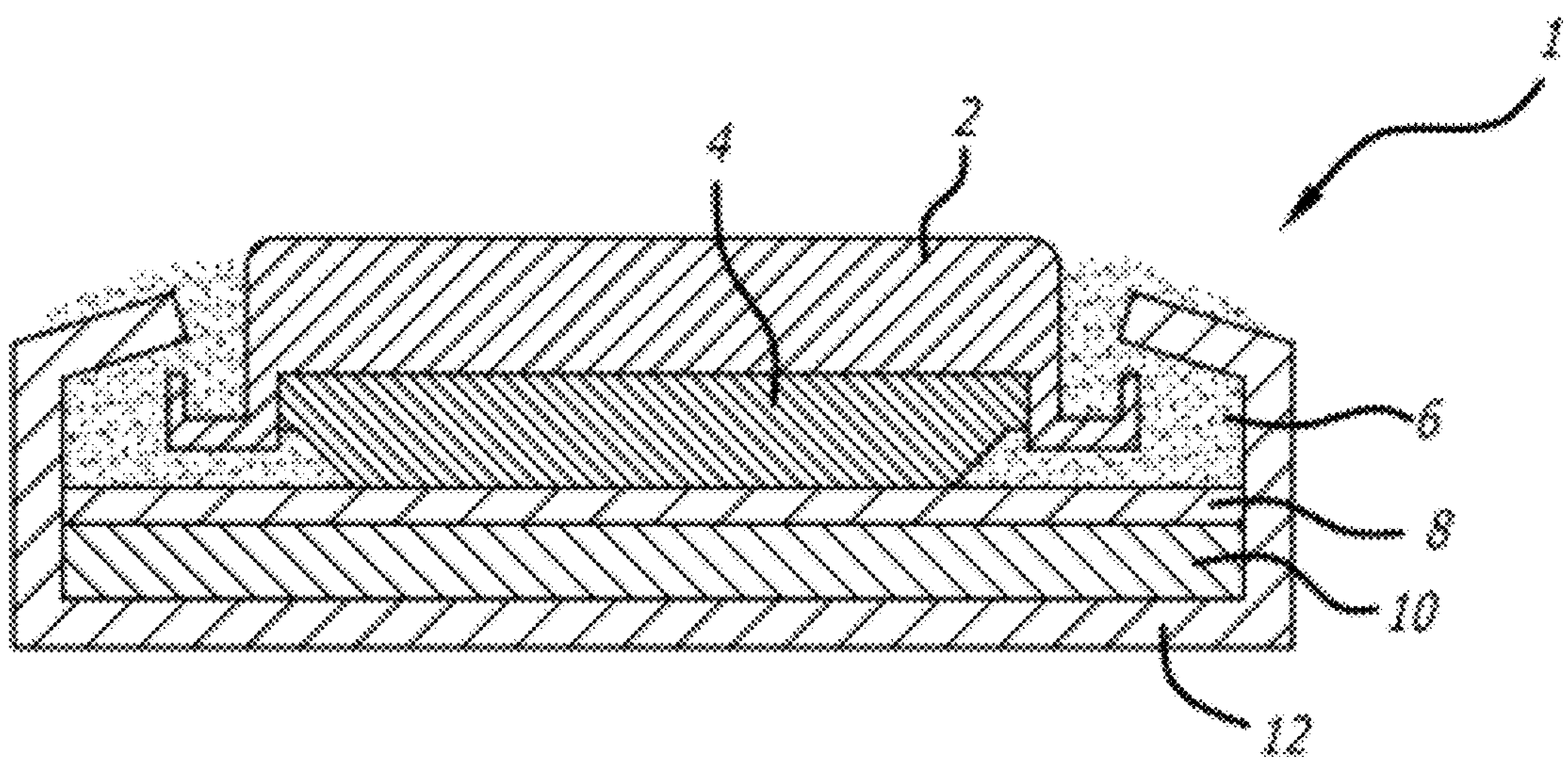
(57) **ABSTRACT**

Improved button cell safety systems, methods and composition are herein disclosed. According to one embodiment, the button cell includes a cathode shell. An insulator ring with an anode cavity is at least partially positioned within the cathode shell. An anode plate is inserted in the insulator ring to engage the anode cavity. A pressure sensitive conductive disc is configured for actuation between an active cell state and a default inactive cell state



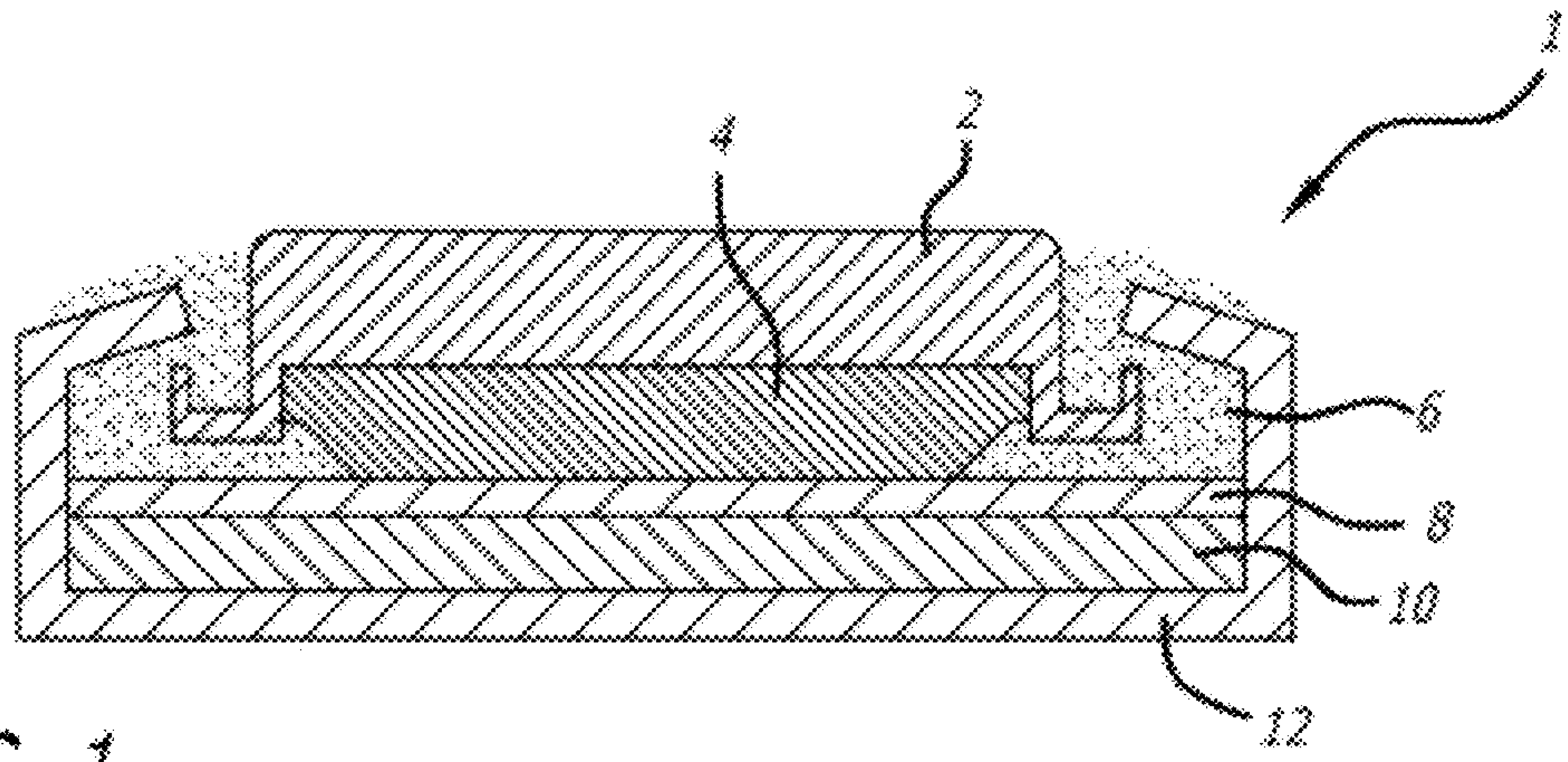


FIG. 1

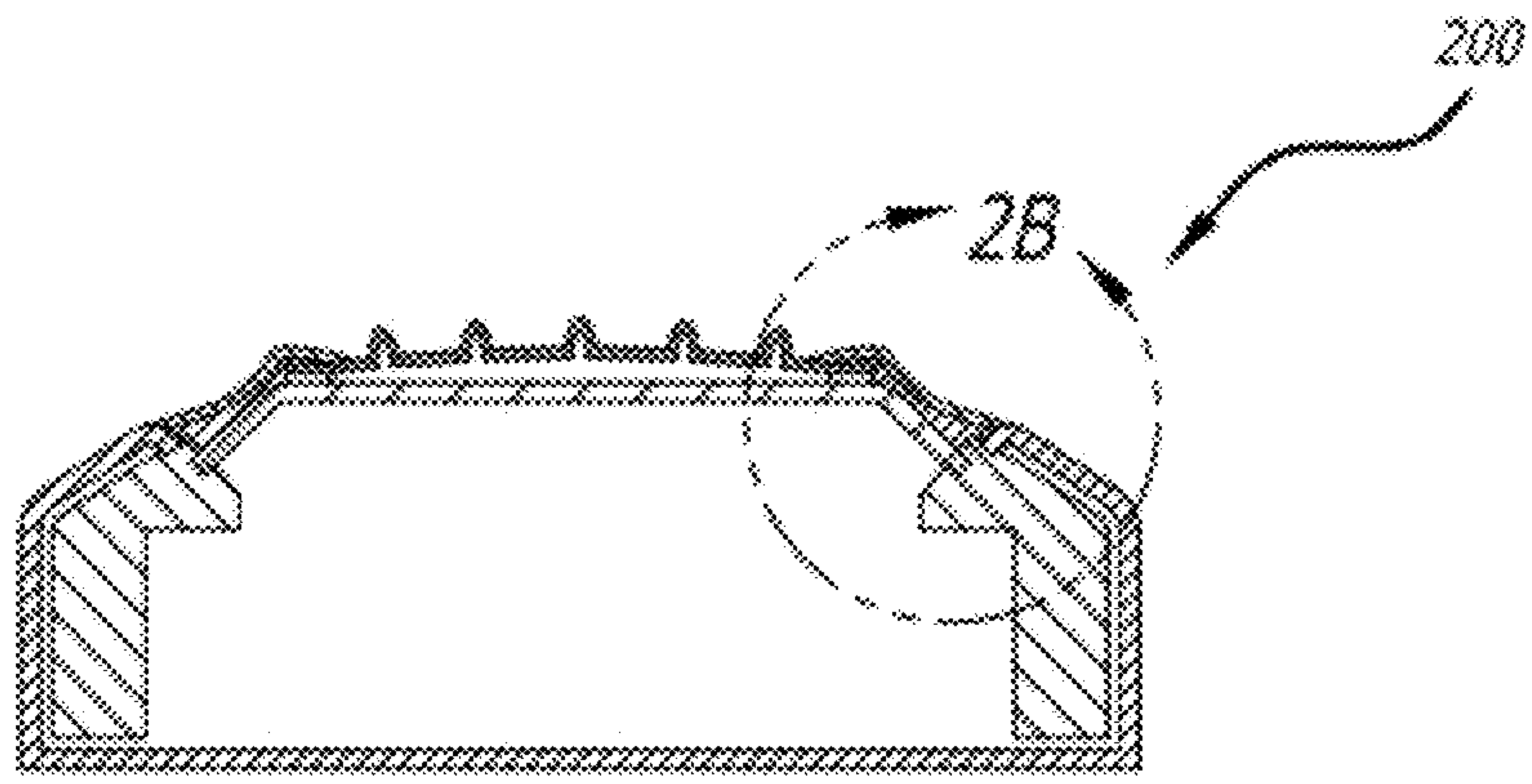


FIG. 2A

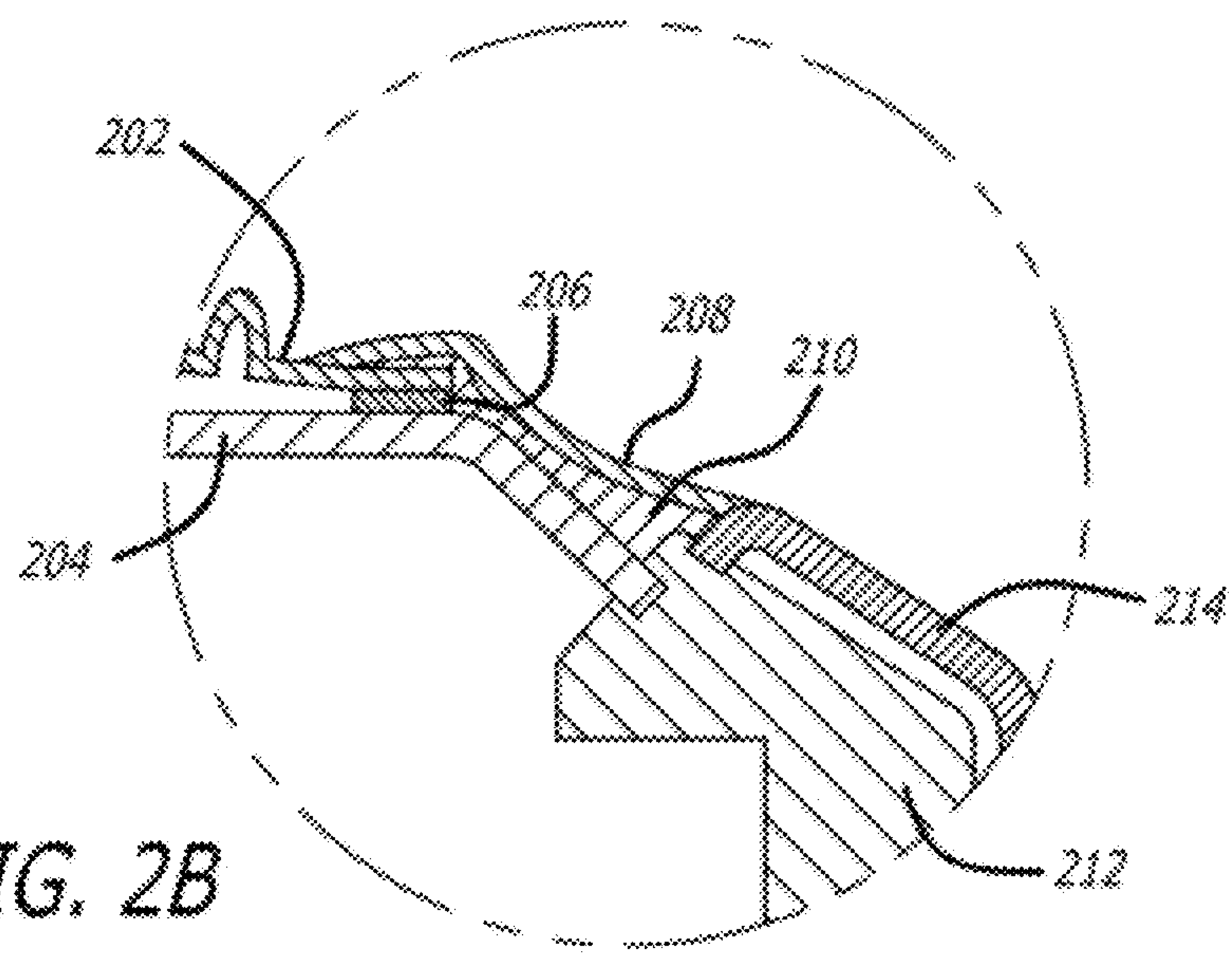


FIG. 2B

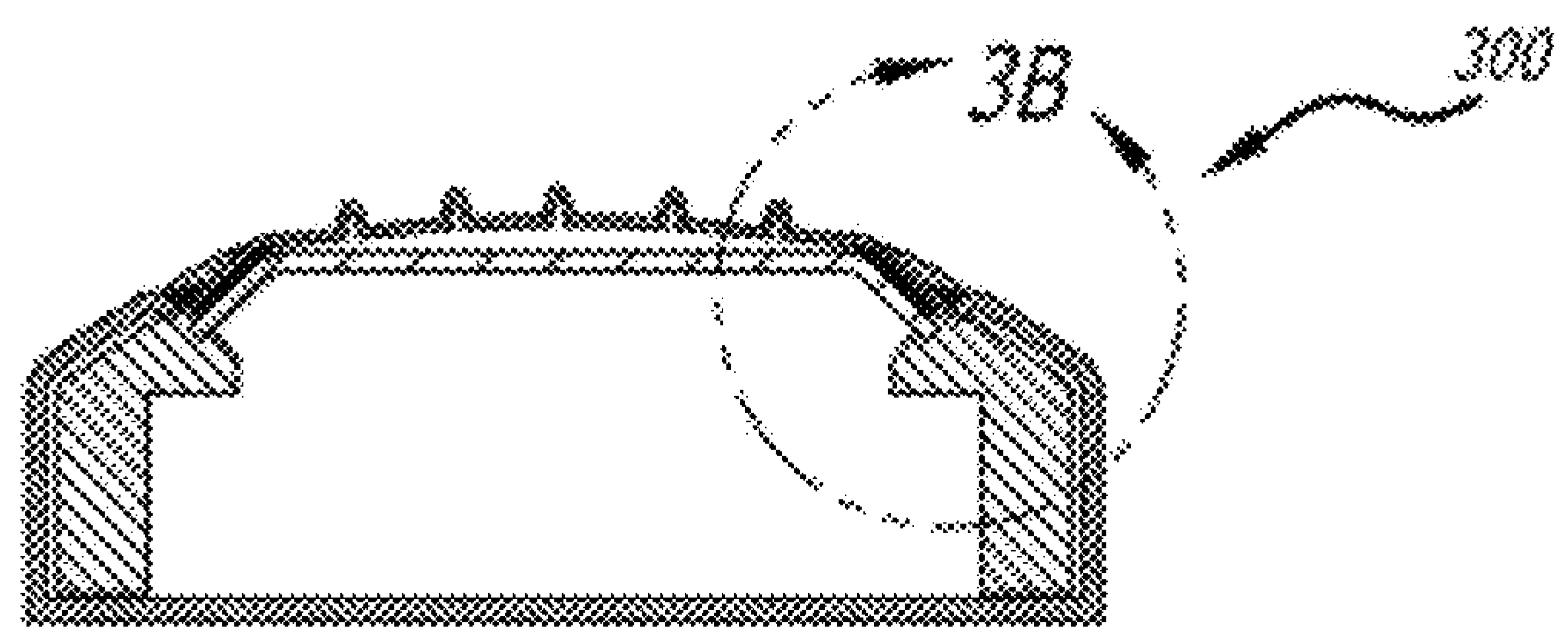


FIG. 3A

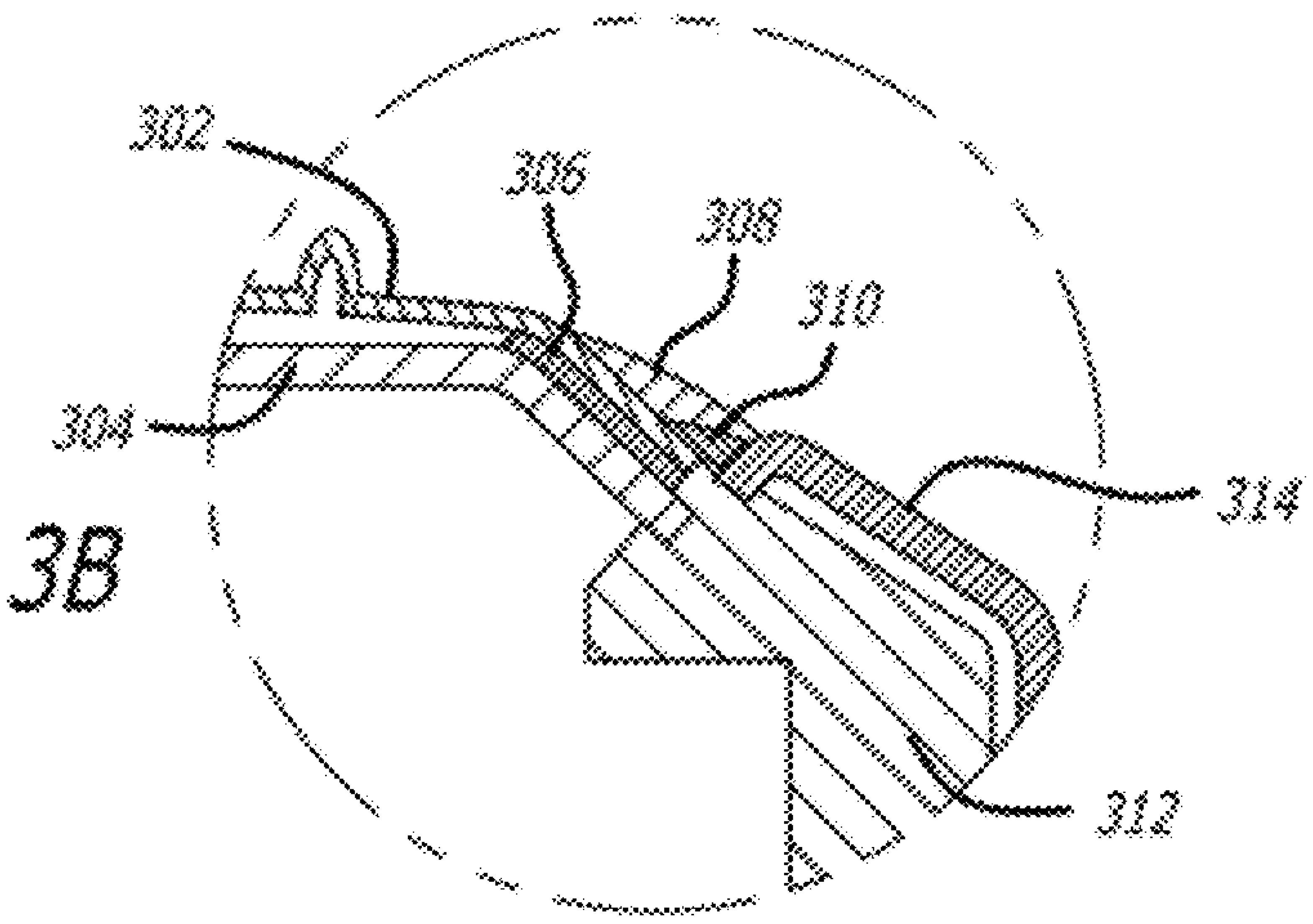


FIG. 3B

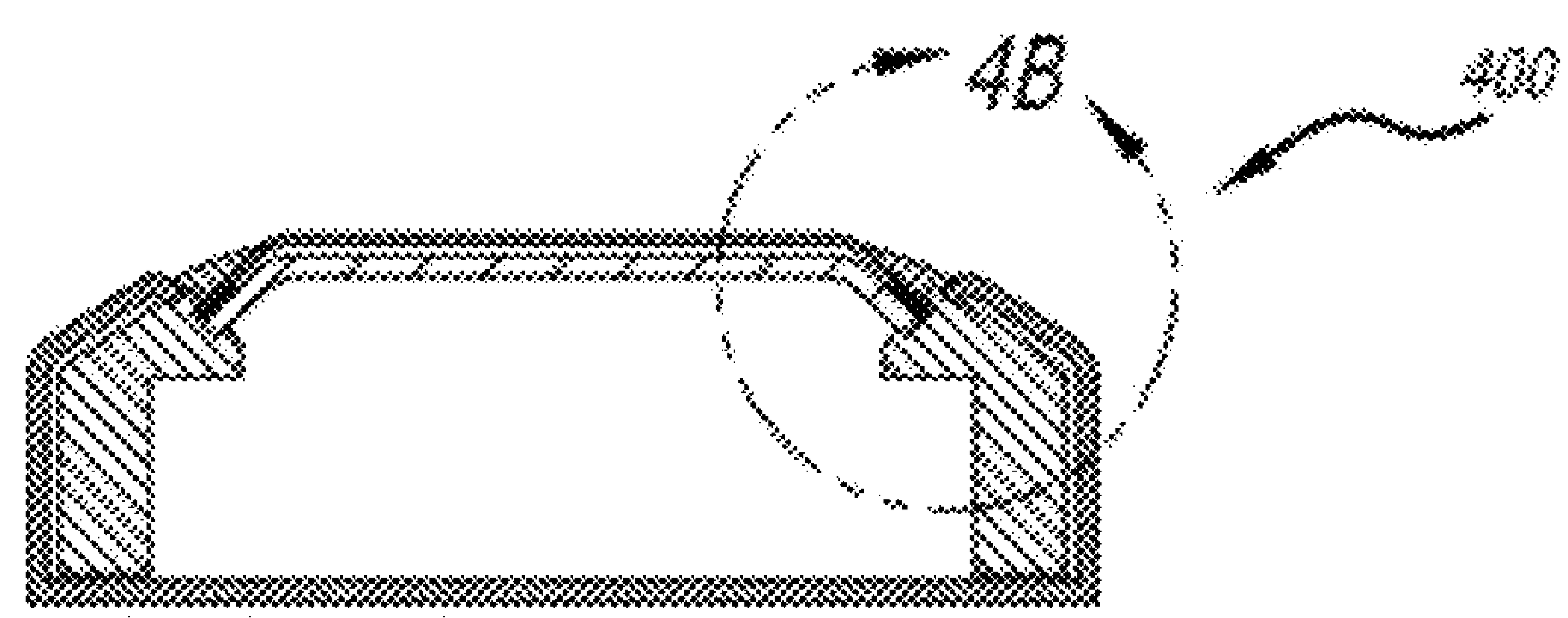


FIG. 4A

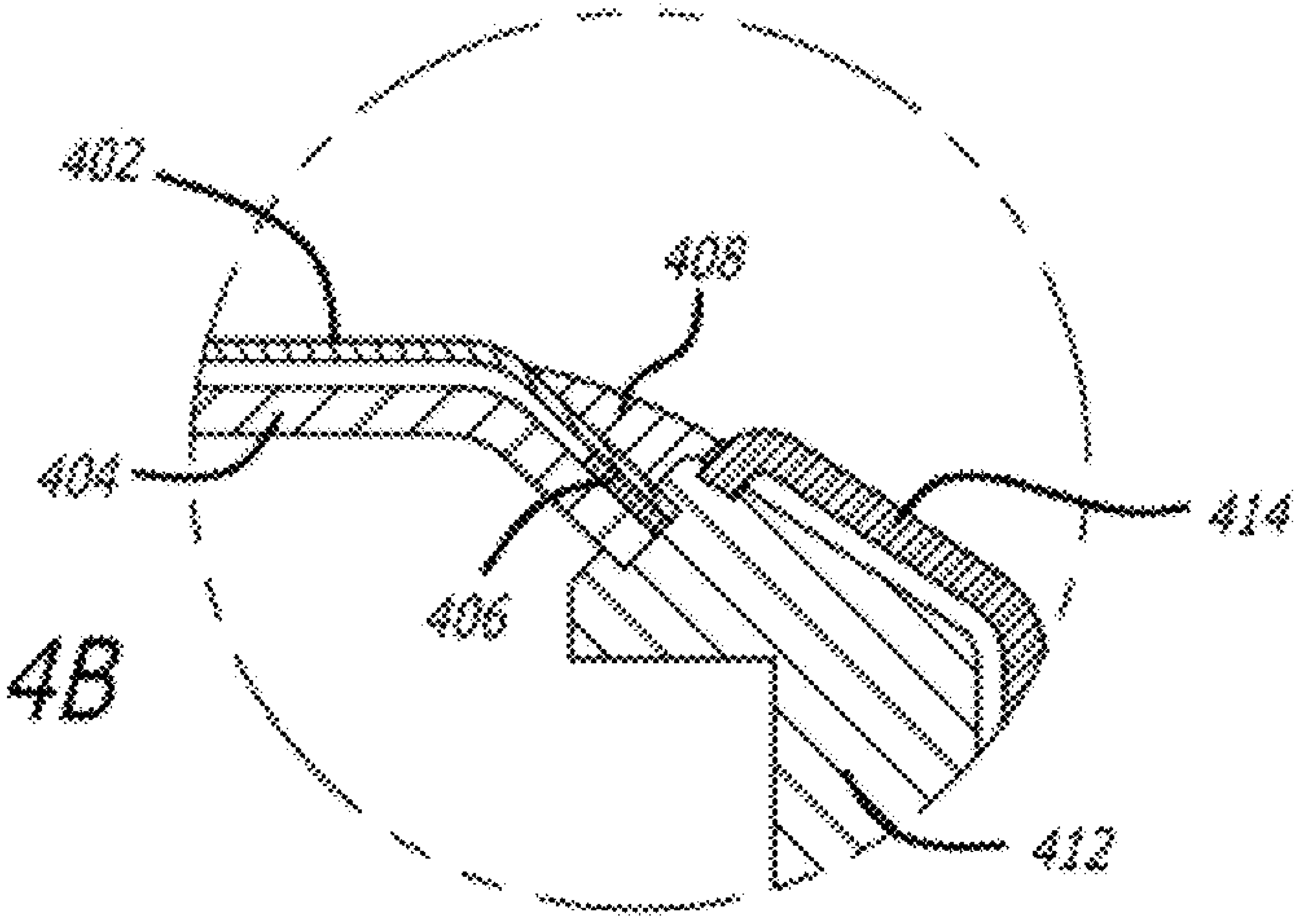


FIG. 4B

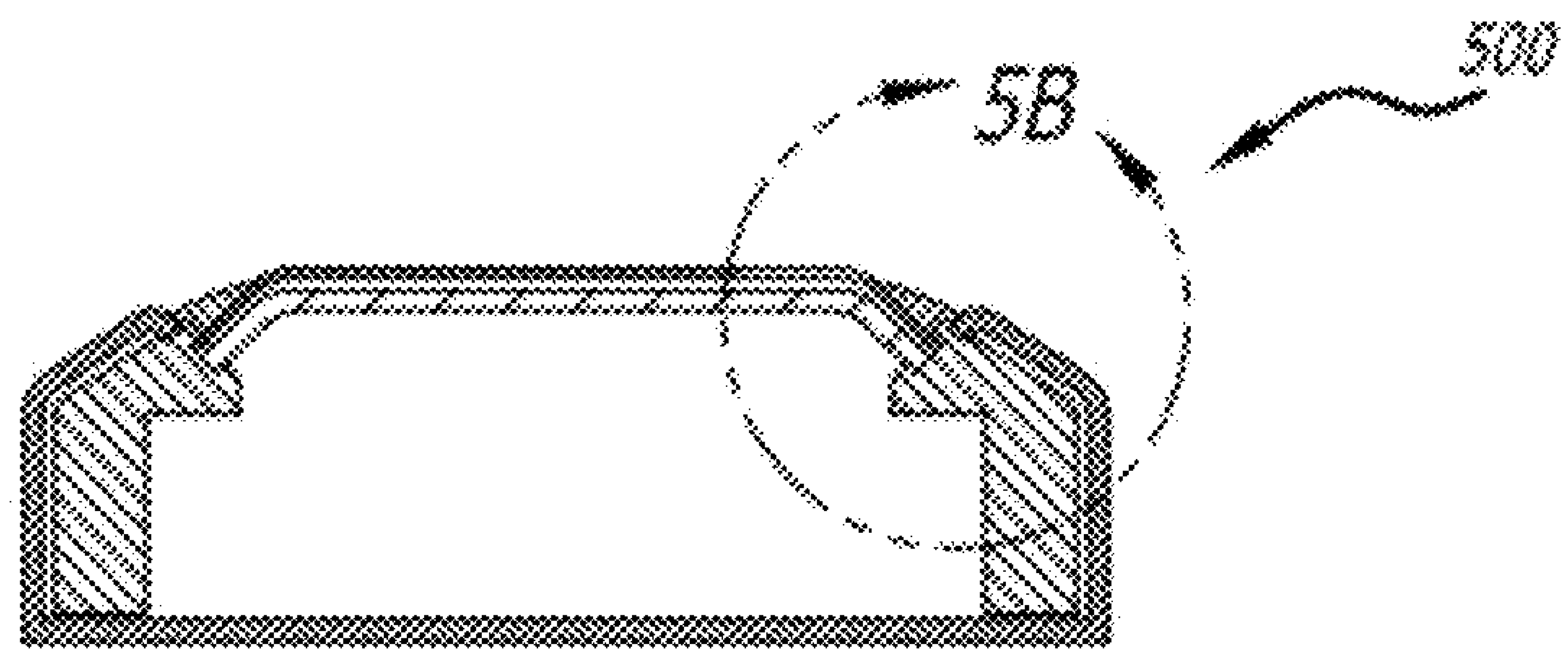


FIG. 5A

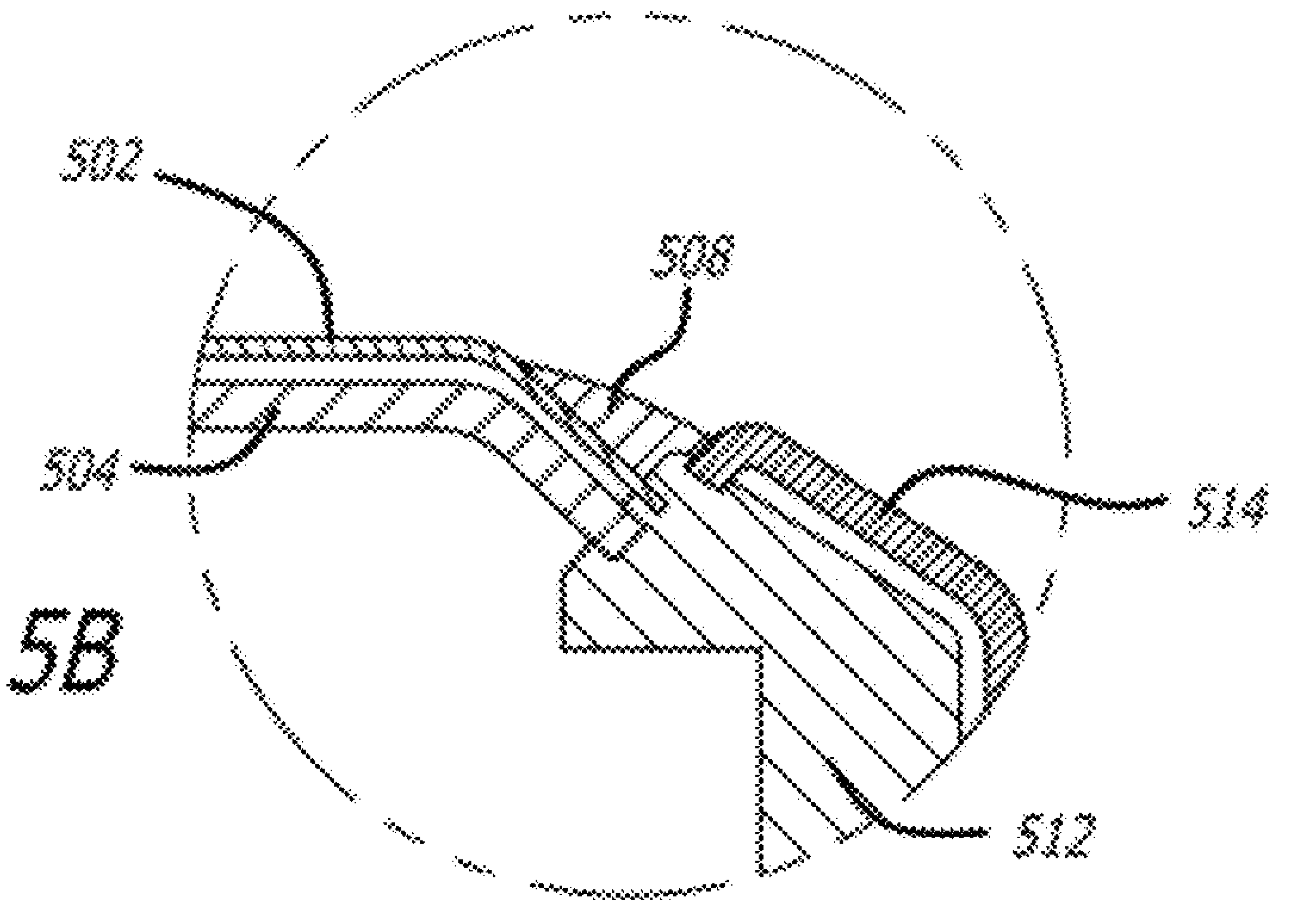


FIG. 5B

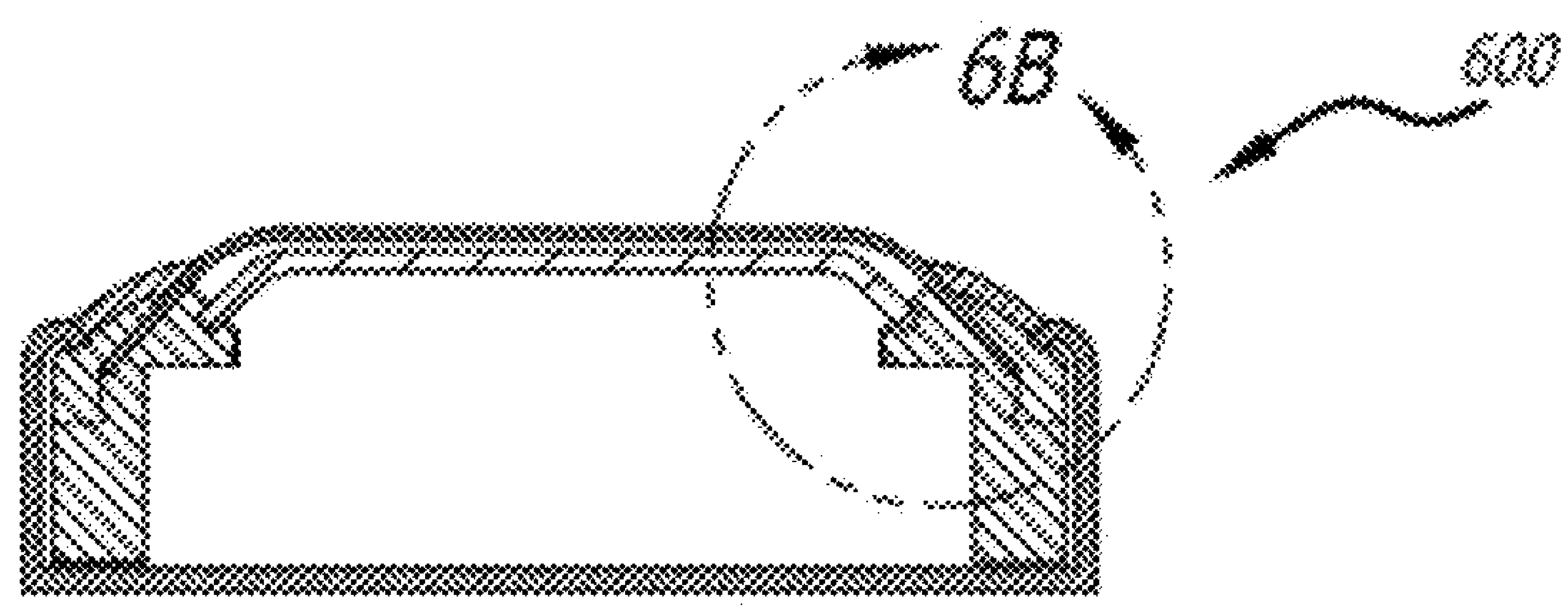


FIG. 6A

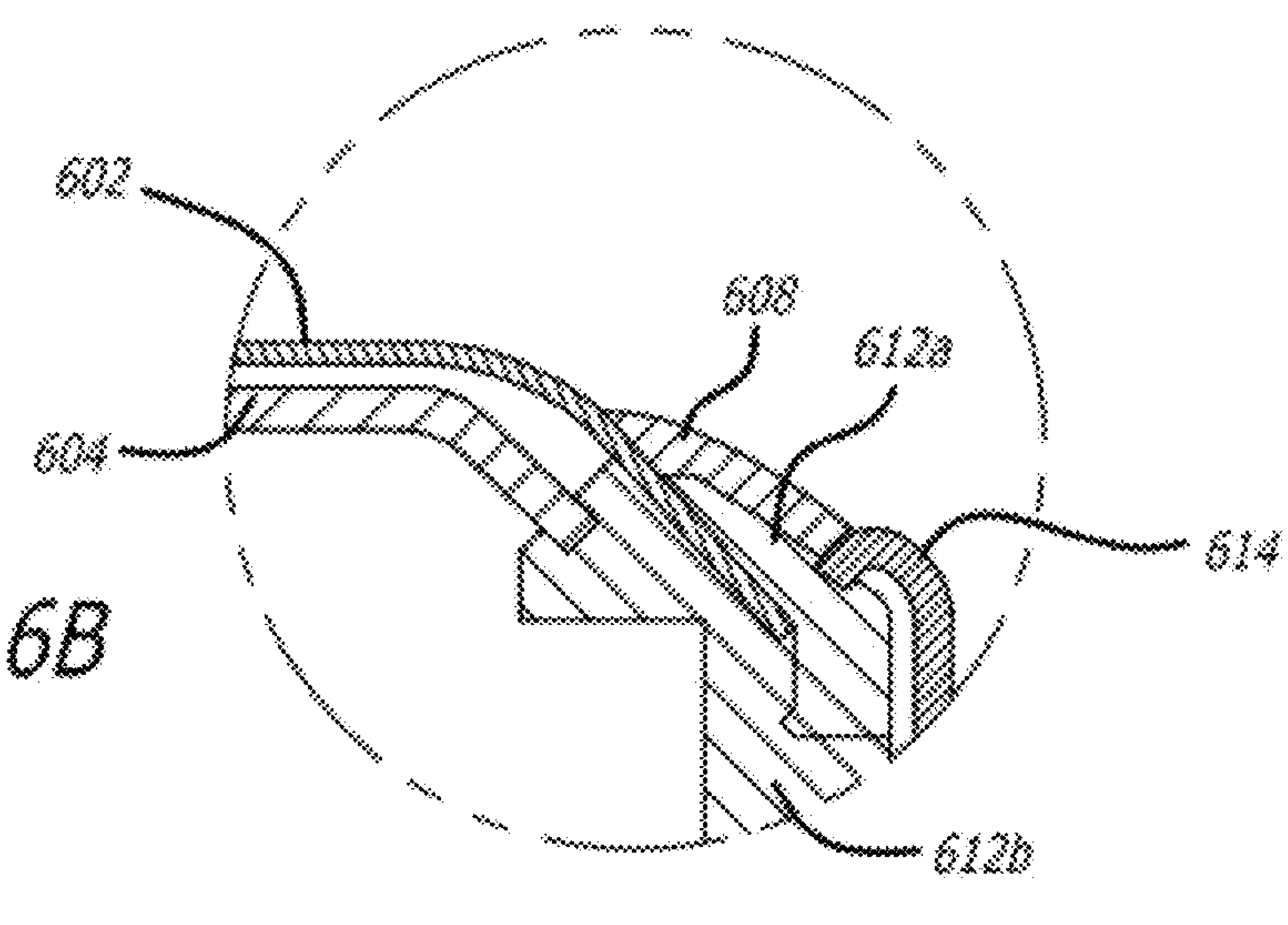


FIG. 6B

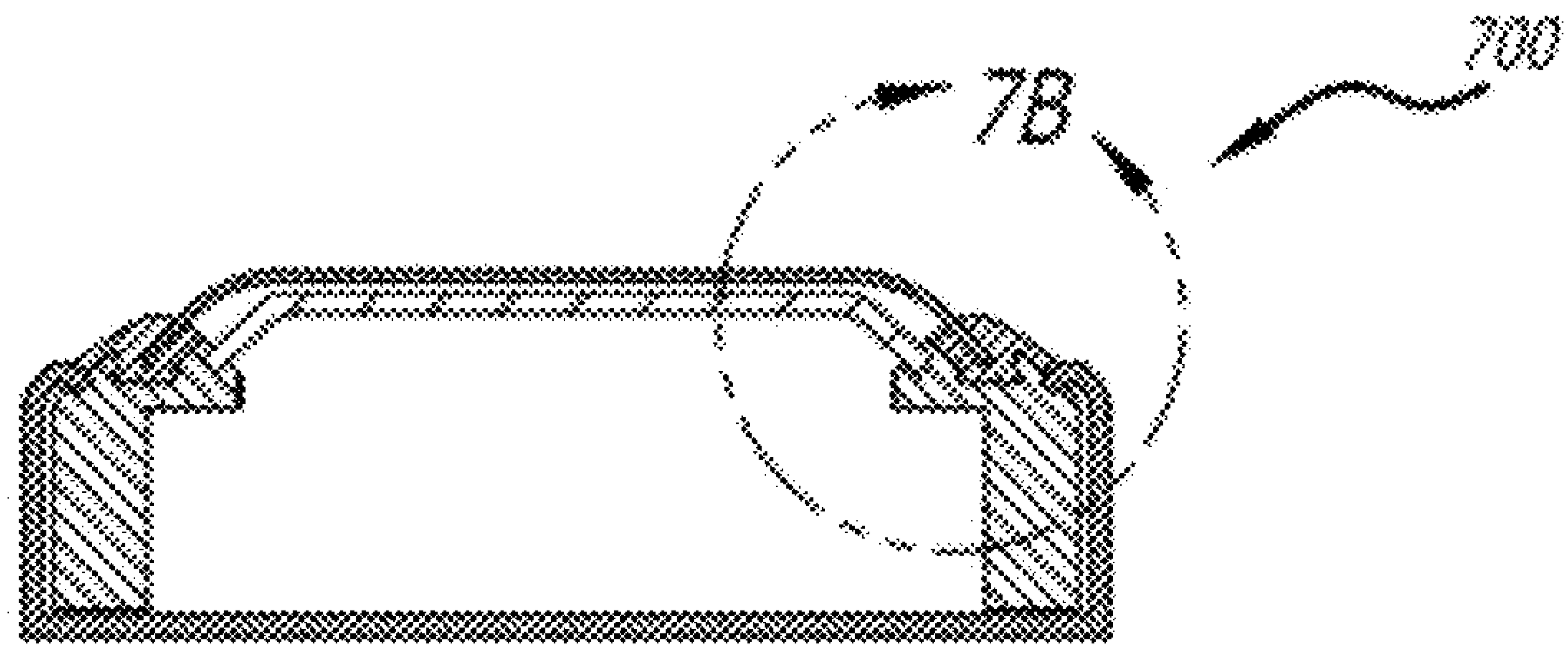


FIG. 7A

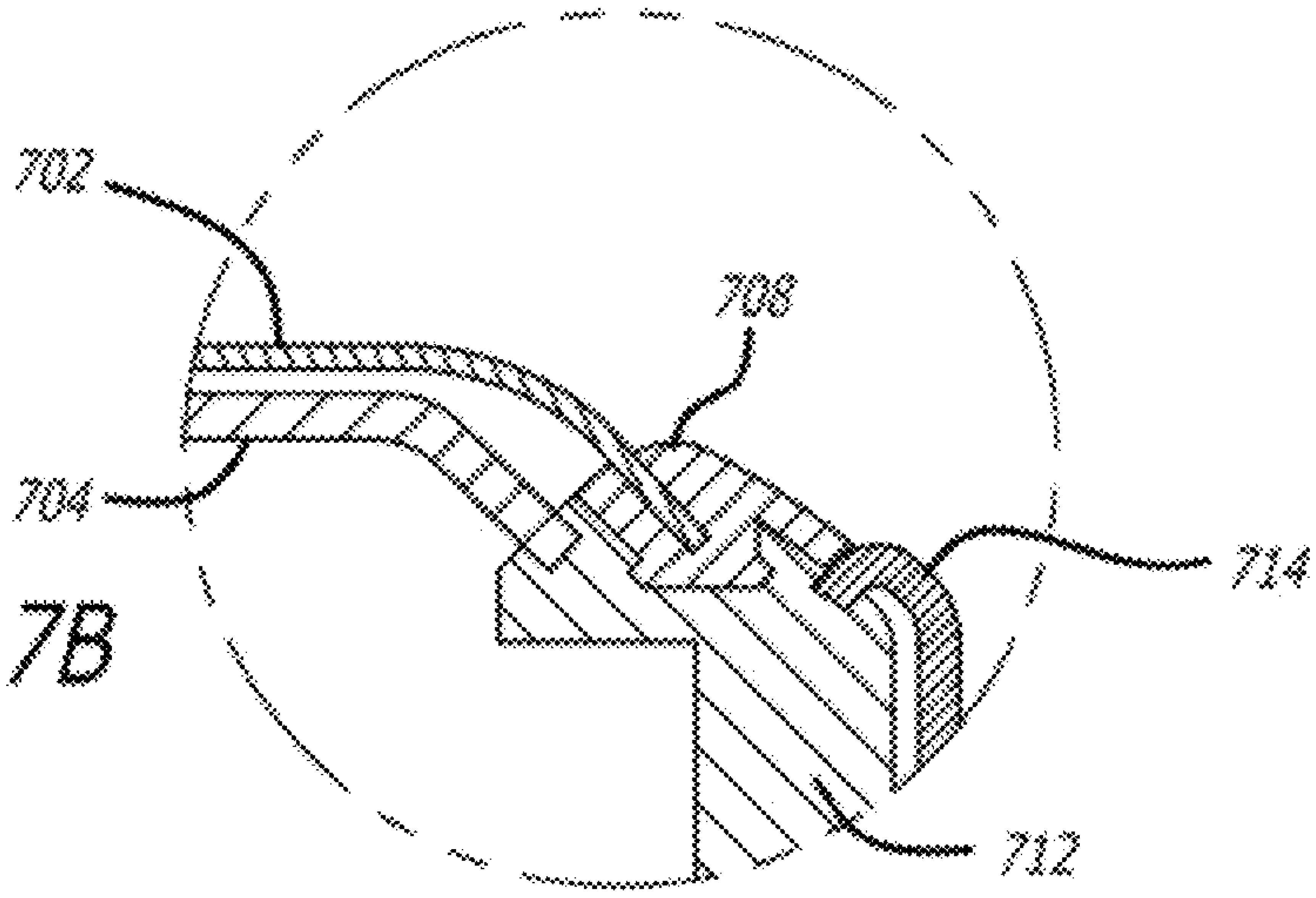


FIG. 7B

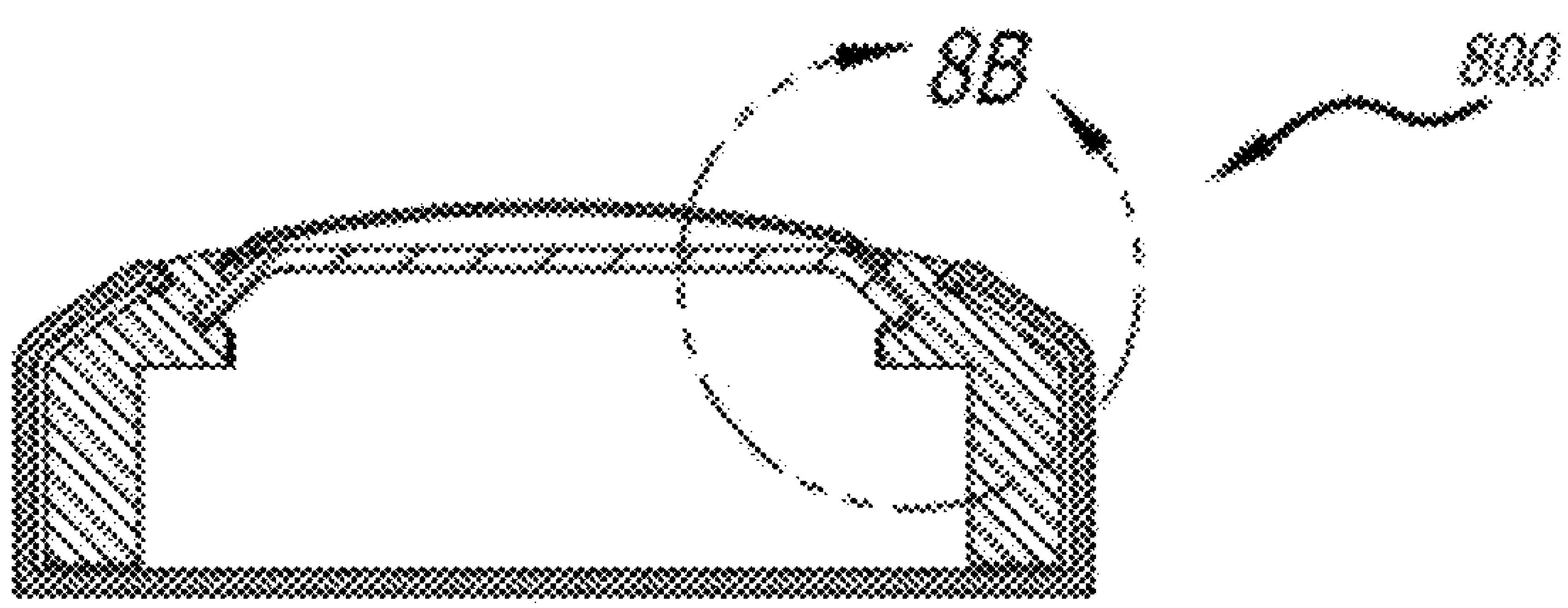


FIG. 8A

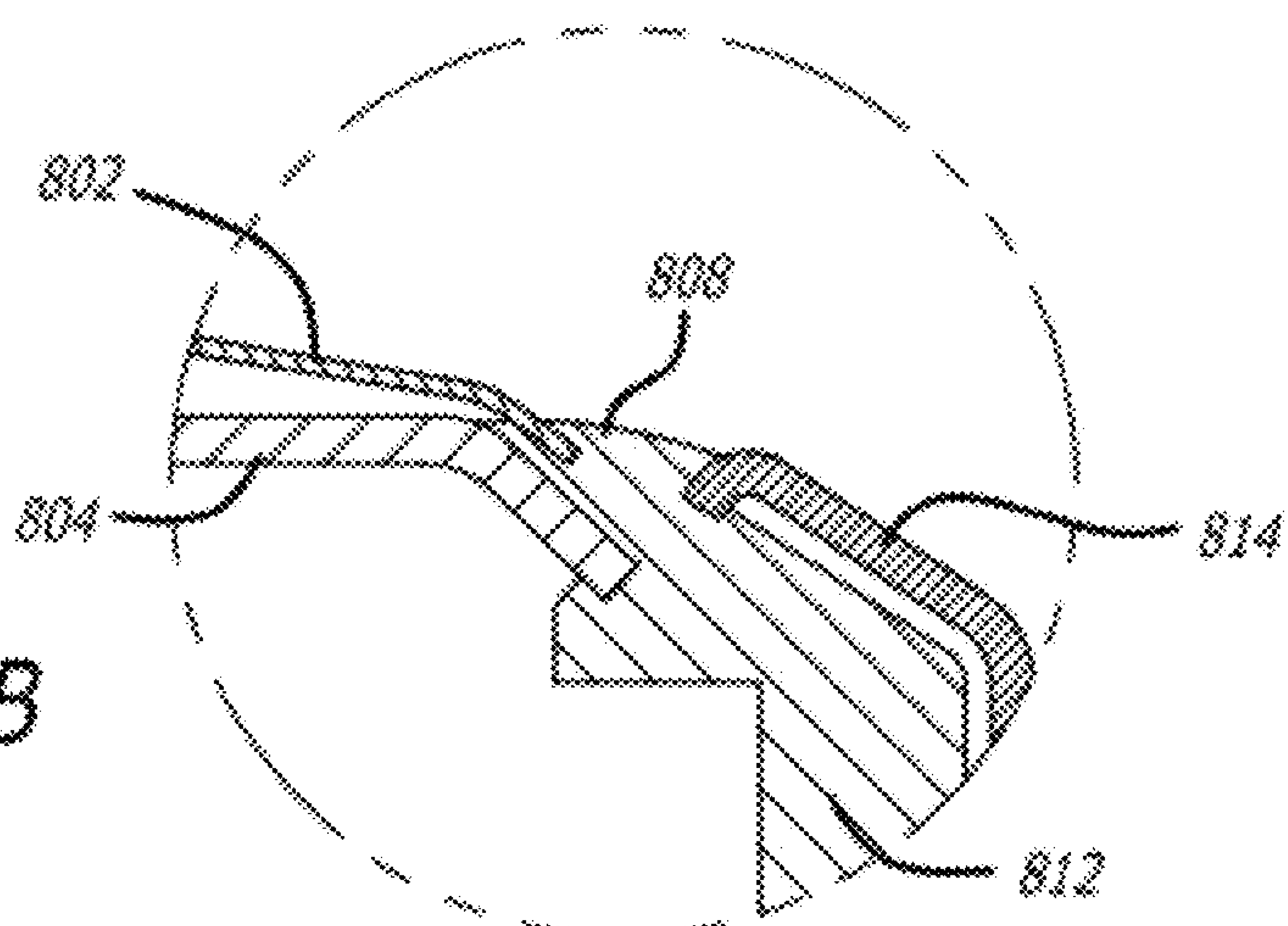


FIG. 8B

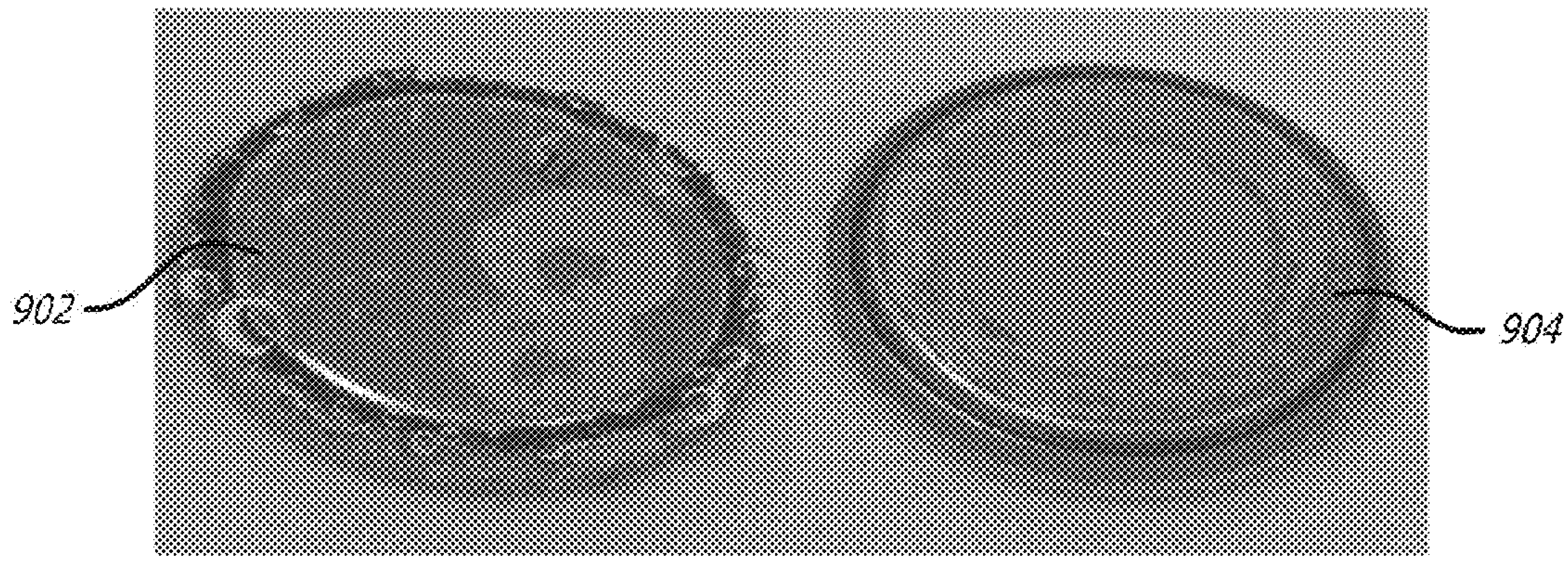

902
904

FIG. 9

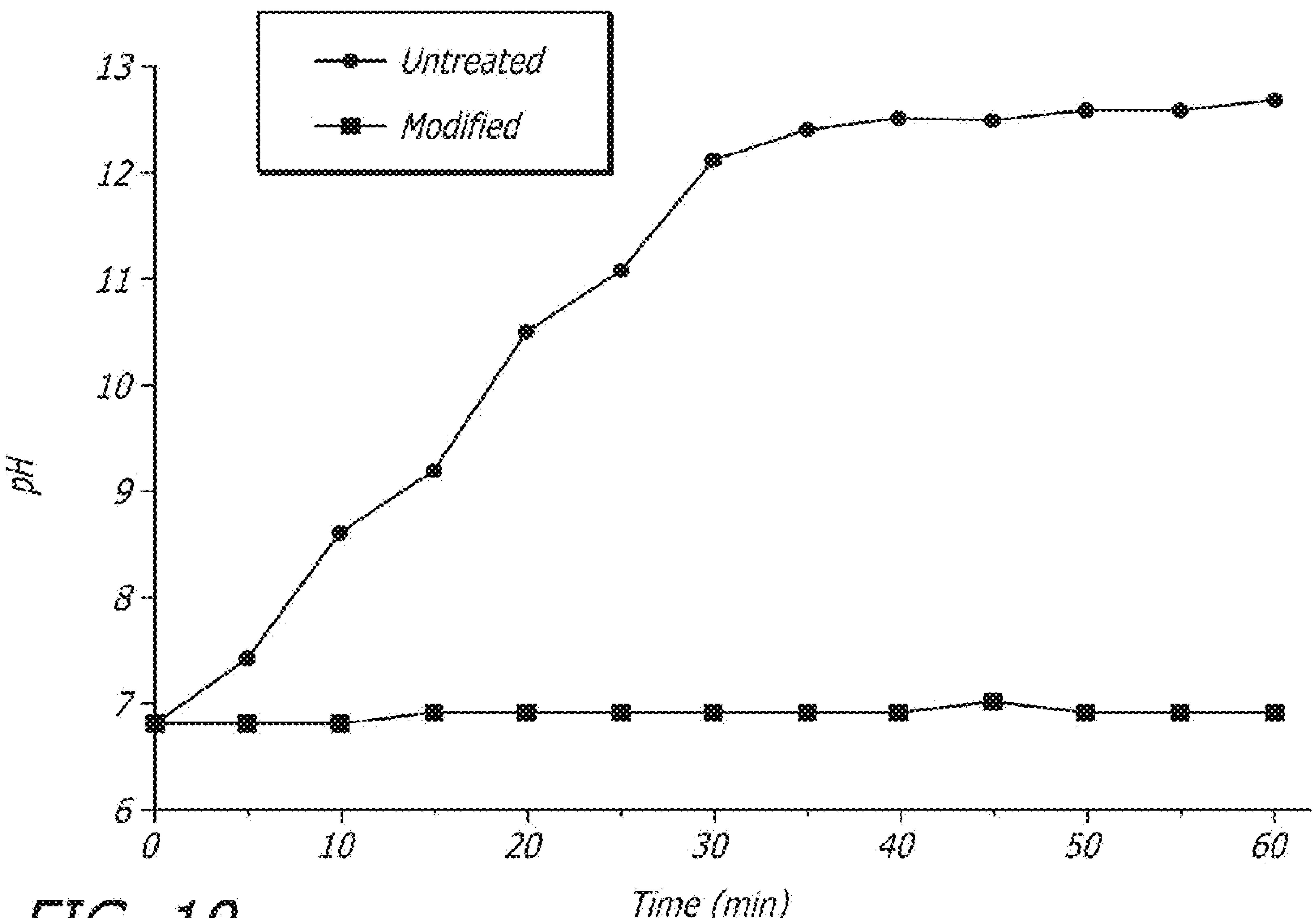

Untreated
Modified
13
12
11
10
9
8
7
6
pH
0
10
20
30
40
50
60
Time (min)

FIG. 10

BATTERY SAFETY SYSTEMS, METHODS AND COMPOSITIONS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from New Zealand patent No. 588,100, entitled "SAFETY MATERIAL AND SYSTEM," filed on Sep. 21, 2010 and PCT application no. PCT/NZ2011/000196, entitled "SAFETY MATERIAL AND SYSTEM," filed on Sep. 21, 2011, which are both incorporated by reference in their entirety, for all purposes, herein.

FIELD OF TECHNOLOGY

[0002] The present disclosure is directed to systems, methods and composition for preventing ingestion of harmful materials. More specifically, the present disclosure is directed to systems, methods and composition for mitigating harmful effects caused by oral contact or ingestion of batteries.

BACKGROUND

[0003] The prevalence of electronic devices, such as watches, remotes, hearing aids, and toys, provides unprecedented convenience and amusement to our life in many ways. It is significantly attributed to button cells. The global market for these thin, portable and affordable power sources is expected to exceed US $1.77 billion by 2014 from US $1.1 billion in 2007.

[0004] As button cells become more popular in the household, the probability of exposure and ingestion of button cells increases. Accidental ingestion, particularly by children, can cause serious injury. Persistent drooling, choking, and even death have been observed in response to button cell ingestion. More than 3,500 cases of button cell ingestion are reported annually in the U.S., and the rising severity of the danger has motivated the U.S. and Australian governments to set up hotlines and websites dedicated button cell ingestion accidents.

[0005] In most cases of battery ingestion, no perceivable signs or symptoms are observed from the victim until serious health problems occur. Moreover, no information about the swallowed battery (such as voltage) is available, which makes it extremely difficult to recognize the accident and provide medical treatment in a timely and appropriate manner.

[0006] To date, various measures have been suggested in order to reduce the possibility of accidental ingestion of foreign objects, such as warning labels or screw-fastened battery compartments, but these have not been effective in terms of child protection. The majority of accidental ingestions occur due to encounters with discarded or unattended batteries after removal from a package or due to improper disposal after use. Conventional attempts for preventing ingestion of foreign objects have fundamental limitations when applied to prevention or mitigation of accidental battery ingestion by children.

[0007] JP 1996-206368 suggests a method of adding a semi-permeable coat layer onto the surface of small objects by dipping the objects in a bath of embittering emetic solution for the prevention of mistaken ingestion. JP 1997-192580 suggests a pen-type applicator of embittering emetic liquid for home use. WO 2007/022563, AU 2006100239 and AU 2005904602 describe a taste aversive composition and packaging.

[0008] Improved button cell safety systems, methods and compositions are herein disclosed.

SUMMARY

[0009] The present disclosure is directed to systems, methods and composition for preventing ingestion of harmful materials. More specifically, the present disclosure is directed to systems, methods and composition for mitigating harmful effects caused by oral contact or ingestion of batteries. Batteries, such as button cell batteries are harmful upon oral contact or ingestion. Harmful side effects from orally contacting or ingesting batteries can include persistent drooling, poisoning, internal burns, esophagus damage and death. Button cell safety systems, methods and compositions are herein disclosed.

[0010] According to one embodiment, the button cell includes a cathode shell. An insulator ring with an anode cavity is at least partially positioned within the cathode shell. An anode plate is inserted in the insulator ring to engage the anode cavity. A pressure sensitive conductive disc is configured for actuation between an active cell state and a default inactive cell state.

[0011] The foregoing and other objects, features and advantages of the present disclosure will become more readily apparent from the following detailed description of exemplary embodiments as disclosed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Embodiments of the present application are described, by way of example only, with reference to the attached Figures, wherein:

[0013] FIG. **1** illustrates a cross-sectional view of an exemplary button cell safety system according to one embodiment;

[0014] FIGS. **2**A-**2**B illustrate a cross-sectional schematic of an exemplary button cell safety system according to another embodiment;

[0015] FIGS. **3**A-**3**B illustrate a cross-sectional schematic of an exemplary button cell safety system according to another embodiment;

[0016] FIGS. **4**A-**4**B illustrate a cross-sectional schematic of an exemplary button cell safety system according to another embodiment;

[0017] FIGS. **5**A-**5**B illustrate a cross-sectional schematic of an exemplary button cell safety system according to another embodiment;

[0018] FIGS. **6**A-**6**B illustrate a cross-sectional schematic of an exemplary button cell safety system according to another embodiment;

[0019] FIGS. **7**A-**7**B illustrate a cross-sectional schematic of an exemplary button cell safety system according to another embodiment;

[0020] FIGS. **8**A-**8**B illustrate a cross-sectional schematic of an exemplary button cell safety system according to another embodiment;

[0021] FIG. **9** illustrates exemplary and comparative button cells during immersion testing; and

[0022] FIG. **10** illustrates a comparison of pH v. time of exemplary and comparative buttons cells during immersion testing.

DETAILED DESCRIPTION

[0023] It will be appreciated that for simplicity and clarity of illustration, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the example embodiments described herein. However, it will be understood by those of ordinary skill in the art that the example embodiments described herein may be practiced without these specific details. In other instances, methods, procedures and components have not been described in detail so as not to obscure the embodiments described herein.

[0024] The present disclosure is directed to button cell safety systems, methods and compositions. Batteries, such as button cell batteries are harmful upon oral contact or ingestion. Harmful side effects from orally contacting or ingesting batteries can include persistent drooling, poisoning, internal burns, esophagus damage and death.

Exemplary Mitigating Compositions

[0025] In the exemplary embodiments herein disclosed a mitigating composition can be applied, adhesively affixed, or bonded to one or more surfaces of a battery, such as a button cell battery. Mitigating compositions can include aversive agent components, colorant components, salivating agent components, emetic components or mixtures thereof.

[0026] Exemplary aversive agent compositions can be applied, adhesively affixed, or bonded to one or more surfaces of a battery, such as a button cell battery. Aversive agents provide offensive and obstructive flavors such as bitterness or pungency. The flavor or odor is released in the mouth to prevent or discourage ingestion of a battery containing the aversive agent on one or more surfaces. The aversive agent can be a composition containing one or more chemical components. In an exemplary embodiment, the overall composition of the aversive agent is preferably less than about 10 percent of the composition by dry weight. In another exemplary embodiment, the overall composition of the aversive agent is preferably about 0.5 to about 1 percent of the composition by dry weight. However, the concentration of the aversive agent may vary depending on the composition and recommended dose of the specific aversive agent.

[0027] In an exemplary embodiment, the aversive agents include at least one of the following components: ammonium benzoate, denatonium benzoate, denatonium saccharide, denatonium chloride, sucrose octaacetate, 2,3-dimethoxystrychnine, quassinoids, flavonoids, including quercetin, absinthin, resinferatoxin, capsaicin, nonivamide, piperine, allyl isothiocyanate and/or mixtures thereof. Sucrose octaacetate, ammonium benzoate, denatonium benzoate, denatonium saccharide and quercetin are bitterants. Capsaicin and nonivamide are pungents.

[0028] In an exemplary embodiment, the aversive agent composition includes at least one of following components: ammonium benzoate, denatonium benzoate, denatonium saccharide, denatonium chloride, sucrose octaacetate, 2,3-dimethoxystrychnine, quassinoids, flavonoids, absinthin, resinferatoxin, capsaicin, piperine, and allyl isothiocyanate.

[0029] In another exemplary embodiment, the aversive agent composition includes sucrose octaacetate, ammonium benzoate, denatonium benzoate, denatonium saccharide and quercetin, capsaicin, nonivamide and/or mixtures thereof.

[0030] Exemplary colorant compositions containing one or more colorants can be applied, adhesively affixed, or bonded to one or more surfaces of a battery, such as a button cell battery. One or more colorants within the colorant compositions promptly and vividly color an area in and/or around the mouth of an ingesting victim by releasing a preferably highly soluble color immediately after the object is placed into the mouth or is otherwise contacted with saliva. The colorant compositions provide visual notice of oral contact or ingestion for prompting an eyewitness, such as a parent to take appropriate and immediate measure to remove the harmful material from the victim's mouth or seek medical attention. The colorant compositions also make it easier to find the object if it has not been swallowed and/or ingested by the victim.

[0031] Exemplary colorant compositions preferably also release colorants upon contact with any other body part that is moist with saliva, such as a child's hand that has been placed in the mouth. One or more colorants contained within the colorant compositions stain the saliva and the body part that has been exposed to saliva. The colorant compositions provide visual notice of oral contact or ingestion for prompting an eyewitness, such as a parent to take appropriate and immediate measure to remove the harmful material from the victim's mouth or seek medical attention.

[0032] In an exemplary embodiment, the colorant compositions are selected to provide an indication to first aid and medical treatment personnel of the identity of the ingested object. A color-coding system exclusively assigning a color to a specific category of harmful substances can be used. The color-coding system permits the selection and prompt initiation of appropriate medical treatment following recognition and identification of the ingested object.

[0033] Exemplary colorant compositions can include food colorants, such as FD&C Red 40; Red 3; D&C Black 3; Black 2; mica-based pearlescent pigment; FD&C Yellow 6; Green 3; Blue 1; Blue 2; titanium dioxide (food grade), edible (activated) carbon, purple and natural extracts to create vivid colors and/or mixtures thereof.

[0034] In an exemplary embodiment, the overall content of the colorant composition is about 5 to about 70 percent of the composition by dry weight, more preferably about 5 to about 10 percent of the composition by dry weight. However the overall content of the colorant composition may vary depending on the recommended dose of the specific colorant(s).

[0035] Exemplary salivating agent compositions can be applied, adhesively affixed, or bonded to one or more surfaces of a battery, such as a button cell battery. The salivating agent composition promotes the secretion of saliva when in oral contact or during ingestion by stimulating the sympathetic and parasympathetic nervous systems to provide a visual indication of harmful oral contact or ingestion of a button cell battery.

[0036] Exemplary salivating agent compositions can include at least one of following components: adipic, ascorbic, citric, fumaric, lactic, malic and tartaric acids; alkyl aryl sulfonates, alkyl sulfates, sulfonated amides and amines, sulfated and sulfonated esters and ethers, alkyl sulfonates, polyethoxlyated esters, monoglycerides, diglycerides, diacetyl tartaric esters of monoglycerides, polyglycerol esters, sorbitan esters and ethoxylates, lactylated esters, or phospholipids such as lecithin, polyoxyethylene sorbitan esters, proplyene glycol esters, and sucrose esters and/or mixture thereof. In an exemplary embodiment, the salivating agent composition comprises citric acid, tartaric acid or a mixture thereof.

[0037] The salivating agent compositions can comprise more than one salivating agent. The overall content of the salivating agent is preferably less than about 10 percent of the composition by dry weight, more preferably about 2 to about 6 percent of the composition by dry weight. However, the overall content may vary depending on the recommended dose of the specific salivating agent(s).

[0038] In an exemplary embodiment, the exemplary colorant compositions are combined with one or more salivating agent compositions to form a mitigating composition that can be placed on, affixed to or bonded to one or more surfaces of a battery, such as a button cell battery. The salivating agent composition promotes the secretion of saliva when in oral contact or during ingestion by stimulating the sympathetic and parasympathetic nervous systems. The use of a salivating agent composition creates more saliva and promotes the release and activity of colorant to provide a more prominent visual indication of harmful oral contact or ingestion.

[0039] Exemplary emetic compositions can be applied, adhesively affixed, or bonded to one or more surfaces of a battery, such as a button cell battery. The emetic composition can induce vomiting by releasing a chemical which irritates gastric mucosa or stimulates the medullary chemoreceptor trigger zone. Advantageously, the emetic compositions promote the instant removal of the button cell battery from the victim's body, especially when applied to an object having a potential health hazard. The emetic may comprise one or more chemicals. The overall content of the emetic is preferably less than 10 percent of the composition by dry weight. However, this may vary depending on the recommended dose of the specific emetic(s).

[0040] In an exemplary embodiment, the emetic composition includes at least one of the following components: syrup of ipecac, 10-chloro-5,10-dihydroarsacridine, 10-chloro-5, 10-dihydrophenarsazine, 5-aza-10-arsenaanthracene chloride, diphenylaminechlorarsine, diphenylaminearsine chloride, diphenylcyanarsine, phenyldichloroarsine and/or mixtures thereof.

[0041] The abovementioned components of the emetic composition are generally blended with a carrier, depending on the potential application. The carrier aids in the adhesion of the emetic composition to a harmful object, such as a battery and can improve the viscosity of the emetic composition to aid in application to the battery.

[0042] In an exemplary embodiment, the carrier comprises about 5 to about 90 percent of the emetic composition by dry weight, preferably about 80 to about 90 percent of the emetic composition by dry weight, more preferably about 85 to about 90 percent of the emetic composition by dry weight.

[0043] In an exemplary embodiment, the carrier comprises a monosaccharide, a disaccharide, a polysaccharide and/or a mixture thereof. Such saccharides are preferably readily soluble in human saliva for a faster action. The carriers can also include an amylase-reactive agent. The amylase-reactive agent can be a modified corn starch, such as a crosslinked and stabilized corn starch. Advantageously, modified corn starch improves the selectivity of the composition towards saliva compared to other liquids, thereby improving the resistance of the composition to other ambient and/or contiguous liquids, such as moisture, humidity and sweat. Ambient and/or contiguous liquids may otherwise adversely affect the durability and performance of the emetic composition.

[0044] In an exemplary embodiment, the emetic composition includes about 10 to about 65 percent, preferably about 10 to about 40 percent, of modified starch by dry weight.

[0045] The emetic composition carrier can also include other components in addition to the monosaccharide, disaccharide and/or polysaccharide. For instance, the carrier can contain a thickening agent including, but are not limited to, xanthan gum, gum arabic and/or mixtures thereof. In an exemplary embodiment, the emetic composition comprises about 1 to about 10 percent, preferably about 1 to about 5 percent, of xanthan gum and/or gum arabic by dry weight.

[0046] The emetic composition carrier can also include an adhesion enhancer that improves adhesion of the composition to a harmful object, such as a battery and also improves the resistance of the composition to other ambient and/or contiguous liquids, such as moisture, humidity and sweat. Ambient and/or contiguous liquids may otherwise adversely affect the durability and performance of the emetic composition. Suitable adhesion enhancers include, but are not limited to, ethyl cellulose, polyvinyl acetate, polyvinyl alcohol and/or mixtures thereof.

[0047] In an exemplary embodiment, the ethyl cellulose comprises about 48-50% of ethoxy groups. In another exemplary embodiment, the emetic composition comprises about 40 to about 75 percent of adhesion enhancer by dry weight. The emetic composition carrier can also contain a preservative including, but not limited to sodium benzoate, potassium sorbate and/or mixtures thereof.

[0048] The emetic composition carrier can also contain a stabilizer, including but not limited to pentaerythritol tetrakis (3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate), tris(2,4-di-tert-butylphenyl)phosphite and poly(4-hydroxy-2,2,6,6-tetramethyl-1-piperidine ethanol-alt-1,4-butanedioic acid) and/or mixtures thereof. The emetic composition carrier can also contain a solvent including, but not limited to, ethyl alcohol, ethyl acetate, t-butyl alcohol, water and/or mixtures thereof.

[0049] The aversive agent compositions, the colorant compositions, the salivating agent compositions and/or the emetic compositions can each be blended with a carrier to facilitate application upon a surface of a harmful material, such as a button cell battery.

[0050] In an exemplary embodiment, the carrier contains modified corn starch, xanthan gum or gum arabic. The carrier can further contain ethyl cellulose or polyvinyl acetate. In another exemplary embodiment, the carrier contains ethyl cellulose, polyvinyl acetate and polyvinyl alcohol.

[0051] The above described carriers can further contain a preservative including sodium benzoate and potassium sorbate and/or a stabilizer including, but not limited to pentaerythritol tetrakis (3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate), tris(2,4-di-tert-butylphenyl)phosphite and/or poly(4-hydroxy-2,2,6,6-tetramethyl-1-piperidine ethanol-alt-1,4-butanedioic acid).

[0052] In an exemplary embodiment, a mitigating composition can be applied, adhesively affixed, or bonded to one or more surfaces of a battery, such as a button cell battery. The mitigating composition contains about 5 to about 10 percent of the composition by dry weight of a colorant composition, about 2 to about 6 percent of the composition by dry weight of a salivating agent composition and a carrier making up about 80 to about 90 percent of the composition by dry weight of the overall content of the mitigating composition. Upon oral contact or ingestion of the button battery, the colorant composition stains the saliva.

[0053] The above described mitigating composition can further includes about 0.5 to about 1 percent of the composition by dry weight of an aversive agent selected from the group consisting of sucrose octaacetate, ammonium benzoate, denatonium benzoate, denatonium saccharide, quercetin, capsaicin, nonivamide and/or mixtures thereof.

[0054] The mitigating compositions herein disclosed can be applied to harmful material or object, such as a button cell battery by any conventional means. For example, a sprayer, roller or brush can be used to apply a mitigating composition in the form of a liquid, aerosol, slurry or other solution. After application, the mitigating composition can be dried by at least partially evaporating the solvent from the composition. The solvent can be evaporated at ambient temperature or by placing the coated harmful object in a warm environment, such as an oven.

[0055] The mitigating composition is typically applied to at least a portion of an external surface of a harmful object, such as a button cell. The mitigating composition can also be incorporated in a component of the button cell, at least a portion of which is exposed to moisture upon immersion of the object.

EXAMPLE MITIGATING COMPOSITIONS

[0056] The following non-limiting examples are provided to illustrate exemplary embodiments and are not intended to limit the scope of this disclosure.

Example Composition 1

[0057] In an exemplary embodiment, a mitigating composition including a salivating component is made by selecting one of the following salivating agents: adipic, ascorbic, aitric, aitric (anhydrous), fumaric, lactic, malic and tartaric acids; pilocarpine, etholetrithione, bethanechol, pyridostigmine, alkyl aryl sulfonates, alkyl sulfates, sulfonated amides and amines, sulfated and sulfonated esters and ethers, alkyl sulfonates, polyethoxlyated esters, mono- and diglycerides, diacetyl tartaric esters of monoglycerides, polyglycerol esters, sorbitan esters and ethoxylates, lactylated esters, or phospholipids such as lecithin, polyoxyethylene sorbitan esters, proplyene glycol esters, and sucrose esters. One or more of the salivating agents is mixed with (1) a amylase-reactive thickening agent, such as crosslinked and stabilized corn starch or xanthan gum/gum Arabic; (2) an adhesion enhancer, such as ethyl cellulose, polyvinyl acetate, or polyvinyl alcohol, (3) a solvent, such as ethyl alcohol, ethyl acetate, t-butyl alcohol or distilled water; (4) a preservative, such as sodium benzoate or potassium sorbate; and (5) a stabilizer, such as pentaerythritol tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate), tris (2,4-di-tert-butylphenyl)phosphite, or poly(4-hydroxy-2,2,6,6-tetramethyl-l-piperidine ethanol-alt-1,4-butanedioic acid) to form a mitigating composition.

Example Composition 2

[0058] In an exemplary embodiment, a mitigating composition including a colorant component is made by slowly mixing 40 ml of corn starch and 5 ml of xanthan gum (or gum arabic) into a 200 ml of solvent mixture (90 ml of ethyl alcohol, 90 ml of ethyl acetate and 20 ml of distilled water) at a temperature of 60° C. The solution was mixed thoroughly using a mechanical stirrer until the overall mixture became slightly viscous. 50 g of ethyl cellulose (48-50% of ethoxy groups), 10 g of polyvinyl acetate and 6 g of polyvinyl alcohol were added into the mixture and stirred well for 5 minutes. 5 g of anhydrous citric acid, 1 g of tartaric acid, 9 g of color, 0.02 g of sodium benzoate, 0.01 g of potassium sorbate, 0.03 g of pentaerythritol tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate), 0.12 g of tris (2,4-di-tert-butylphenyl)phosphite and 0.03 g of poly(4-hydroxy-2,2,6,6-tetramethyl-1-piperidine ethanol-alt-1,4-butanedioic acid) were slowly introduced and mixed well.

[0059] After a thorough blending, the overall pH of the mixture was adjusted to be in the range of 6.7-6.9. If the composition is too acidic, a small amount of sodium hydroxide solution (0.1 M) can be carefully added. Finally, a colorant can be added to provide visual indication of oral contact or ingestion. Colorants can include, but are not limited to D&C black 3, black 2, edible (activated) carbon, mica-based pearlescent pigment, FD&C yellow 6, green, green 3, blue 1, blue 2, titanium dioxide (food grade), purple and natural extracts to create vivid colors.

Example Composition 3

[0060] In an exemplary embodiment, a mitigating composition is made by slowly mixing 60 g of modified (crosslinked and stabilized) corn starch and 7.5 g of xanthan gum 200 ml of heated (60° C.) solvent solution (90 ml of ethyl alcohol, 90 ml of ethyl acetate and 20 ml of distilled water) and mixed thoroughly using a mechanical stirrer until the overall mixture became slightly viscous. 50 g of ethyl cellulose (48-50% of ethoxy groups), 10 g of polyvinyl acetate and 6 g of polyvinyl alcohol were added into the mixture and stirred well for 5 minutes. 5 g of anhydrous citric acid, 1 g of tartaric acid, 9 g of colour, 0.02 g of sodium benzoate, 0.01 g of potassium sorbate, 0.03 g of pentaerythritol tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate), 0.12 g of tris(2,4-di-tert-butylphenyl)phosphite and 0.03 g of poly(4-hydroxy-2,2,6,6-tetramethyl-1-piperidine ethanol-alt-1,4-butanedioic acid) were slowly introduced and mixed well.

[0061] After a thorough blending, the overall pH of the mixture was adjusted to be in the range of 6.7-6.9. If the mixture was too acidic, a small amount of sodium hydroxide solution (0.1 M) is carefully added. Finally, a colorant can be added to provide visual indication of oral contact or ingestion. Colorants can include, but are not limited to D&C black 3, black 2, edible (activated) carbon, mica-based pearlescent pigment, FD&C yellow 6, green, green 3, blue 1, blue 2, titanium dioxide (food grade), purple and natural extracts to create vivid colors.

[0062] The exemplary mitigating compositions outlined in Tables 1-2 were prepared following the procedure described with respect to Example Composition 3.

TABLE 1

Exemplary Mitigating Colorant Compositions

	Composition 1	2	3	4	5	6
Colorant	9 g	9 g	9 g	9 g	9 g	9 g
Modified corn starch	60 g	60 g	60 g	60 g	30 g	30 g
Xanthan gum	7.5 g				3 g	3 g
Gum Arabic		7.5 g	7.5 g	7.5 g		
Ethyl cellulose	50 g	50 g	50 g	50 g	50 g	50 g
Polyvinyl acetate	10 g	10 g	10 g	10 g		
Polyvinyl alcohol	6 g	6 g	6 g	6 g		
Citric acid (anhydrous)	5 g	5 g	5 g	5 g	3 g	1 g
Tartaric acid	1 g	1 g	1 g	1 g	1 g	1 g
Ethyl alcohol	90 ml	90 ml	90 ml	90 ml	100 ml	100 ml
Ethyl acetate	90 ml	90 ml	90 ml	90 ml	100 ml	100 ml
Distilled Water	20 ml	20 ml	20 ml	20 ml		
Sodium benzoate	0.02 g	0.02 g	0.02 g	0.02 g		
Potassium sorbate	0.01 g	0.01 g	0.01 g	0.01 g		
Pentaerythritol Tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate)	0.03 g	0.03 g	0.03 g	0.03 g		
Tris(2,4-di-tert-butylphenyl)phosphite	0.12 g	0.12 g	0.12 g	0.12 g		
Poly(4-hydroxy-2,2,6,6-tetramethyl-1-piperidine ethanol-alt-1,4-butanedioic acid)	0.03 g	0.03 g	0.03 g	0.03 g		
Sucrose octaacetate, ammonium benzoate, denatonium benzoate, denatonium saccharide or quercetin			1 g			
Capsaicin or nonivamide				1 g		
Colour strength (immersion in artificial saliva)	strong	strong	strong	strong	strong	strong
Adhesion strength (peeled off an adhesive tape piece)	strong	strong	strong	strong	strong	strong
Tackiness	high	high	high	high	med-hi	med-hi
Colourfastness to moisture (rubbed lightly with a damp cloth)	high	high	high	high	high	high

TABLE 2

Exemplary Mitigating Colorant Compositions

	Composition 7	8	9	10	11	12
Colorant	5 g	5 g	5 g	5 g	5 g	5 g
Modified corn starch	30 g	30 g	10 g	10 g	5 g	
Xanthan gum	3 g	3 g	1 g	1 g	1 g	
Ethyl cellulose	50 g					
Polyvinyl acetate		50 g	50 g			
Citric acid (anhydrous)	3 g	3 g	3 g			
Tartaric acid	1 g	1 g	1 g			
Ethyl alcohol	50 ml	150 ml	150 ml	150 ml	150 ml	150 ml
Ethyl acetate	150 ml	50 ml				
t-Butyl alcohol			50 ml			
Colour strength (immersion in artificial saliva)	med-hi	med-hi	med-hi	med-hi	med-hi	med-hi
Adhesion strength (peeled off an adhesive tape piece)	strong	strong	strong	strong	medium	low
Tackiness	med-hi	med-hi	medium	med-lo	low	low
Colourfastness to moisture (rubbed lightly with a damp cloth)	high	high	med-hi	med-hi	medium	low

Colorant Composition Testing

[0063] The exemplary colorant composition outlined in Tables 1-2 were applied onto the surface of button cells, for instance on the conductive disc, leaving a circular area in the center having a diameter of 12-14 mm. The colorant composition was applied by a sprayer, roller and brush to impart a layer on the button cells not exceeding 0.2 mm in thickness. The weight increase of the button cells due to the colorant composition (after drying) did not exceed 0.1 g. The button cells including colorant compositions were immersed in an artificial saliva mixture outlined in Table 3. The colorants in the colorant compositions diffused in the artificial saliva, coloring the artificial saliva within a few seconds after immersion.

Exemplary Button Cell Safety Systems

[0064] FIG. **1** illustrates a cross-sectional view of an exemplary button cell safety system **1** according to one embodiment. An exemplary mitigating composition can be applied to one or more surfaces of the button cell **1** to prevent or mitigate harmful effects caused by oral contact or ingestion of a button cell **1**. As disclosed herein, mitigating compositions can include an aversive agent component, a colorant component, a salivating agent component, an emetic component or mixtures thereof. A multi-component mitigating composition can provide any combination of the following functionalities: (1) the colorant and salivating components can provide visual indication of ingestion or oral contact; (2) the aversive agent component can prevent or deter ingestion or oral contact; and (3) the emetic component can reverse ingestion by causing the victim to vomit.

[0065] The button cell **1** illustrated in FIG. **1** includes anodes **2**, **4**, an insulating element **6**, a separator **8**, and cathodes **10**, **12**. A separator **8** is placed between the anodes **2**, **4** and cathodes **10**, **12** to enable ions, but not electrons, to transfer between the cathodes and anodes (electrodes) while preventing the electrodes from directly contacting each other and creating an electrical short circuit. The mitigating compositions herein disclosed can be applied, adhesively affixed, or bonded to one or more surfaces of the button cell **1**. The mitigating composition can be applied to the any external or exposed surface of the button cell **1** as an additional layer in the manufacturing process.

[0066] In particular, the mitigating compositions herein disclosed can be applied to the insulating element **6** of the button cell **1**. The mitigating composition can be applied to the insulating element **6** of the button cell **1** as an additional layer in the manufacturing process or the composition can be integrated with the insulating element **6** by compounding with nonconductive polymer materials such as rubbers including NR (natural rubber), NBR (nitrile-butadiene rubber), EPDM (ethylene-propylene diene monomer), EVA (ethylene-vinyl acetate copolymer), polyethylene, and polypropylene.

[0067] The colorant component can provide a distinctive indication of battery ingestion and moreover a visual identification of the specific type of battery by, for example, applying different colors to different kinds of batteries. The color can be selected to indicate the voltage of the battery and identify higher voltage batteries, which cause more serious health hazards.

[0068] FIGS. **2**A-**2**B illustrate a cross-sectional schematic of an exemplary button cell safety system **200** according to another embodiment. FIG. **2**A illustrates a cross-sectional view of the entire button cell assembly **200**, and FIG. **2**B illustrates a close-up, cross-sectional view of a portion of the button cell assembly **200**. The button cell **200** includes a pressure sensitive conductive disc **202**, an anode **204**, an adhesive insulator **206**, a mitigating composition **208**, a sealing compound **210**, an insulator ring **212** and a cathode **214** that make up different layers of the cell assembly **200**.

[0069] The cathode **214** can make up the outer shell of the button cell **200**. The anode **204** disc or plate and/or the insulator ring **212** can be at least partially disposed within the cathode shell **214**. The anode **204** and cathode **214** can be positioned to abut or engage a surface or cavity within the insulator ring **212**. The insulator ring **212** separates the anode **204** from the cathode **214**, forms a layer of insulation and prevents conductive contact between the anode **204** and cathode **214**.

[0070] The conductive disc **202** is a conductive element positioned on top of an adhesive insulator **206** layer, which separates the conductive disc **202** from the anode **204** and prevents conductive contact between the conductive disc **202** and the anode **204** when the cell **200** is not in use. In an exemplary embodiment, the adhesive insulator **206** layer separates the conductive disc **202** from the anode **204** by less than 1 mm of clearance. The adhesive insulator **206** layer can be applied first on top of a flat surface of the anode **204** before the conductive disc **202** is adhesively applied on top of the adhesive insulator **206** layer by applying pressure to promote firm adhesion between layers. The adhesive insulator **206** can also be applied to the conductive disc **202** first before the combined assembly is attached to a flat surface of the anode **204** by applying pressure to promote firm adhesion between layers.

[0071] A sealing compound **210** can be applied on at least a portion of the conductive disc **202**, the exposed portion of the anode **204** and/or a portion of the cathode **214** to form a water tight seal. The sealing compound **210** can be applied on a portion of the conductive disc **202**, leaving at least a portion of the conductive disc **202** uncovered and exposed for electrical contact. The anode **204** is completely contained and sealed within the cell **200**.

[0072] A mitigating composition **208** can be applied on at least a portion of the cathode **214**, the sealing compound **210** and/or and the conductive disc **202**. The mitigating composition **208** can be applied on a portion of the conductive disc **202**, leaving at least a portion of the conductive disc **202** uncovered and exposed for electrical contact. An exemplary mitigating composition **208** can be applied to any surface of the button cell **200** to prevent or mitigate harmful effects caused by oral contact or ingestion of a button cell **200**. As disclosed herein, the mitigating composition **208** can include an aversive agent component, a colorant component, a salivating agent component, an emetic component or mixtures thereof. A multi-component mitigating composition **208** can provide any combination of the following functionalities: (1) the colorant and salivating components can provide visual indication of ingestion or oral contact; (2) the aversive agent component can prevent or deter ingestion or oral contact; and (3) the emetic component can reverse ingestion by causing the victim to vomit.

[0073] The cell **200** can be placed in a warm environment or oven to dry the various layers during and after assembly of the cell **200**. Dimensional increase caused by drying the adhesive insulator **206** layer and sealing compound **210** can be controlled not to exceed 0.5 mm. Dimensional increase caused by drying the mitigating composition **208** can be controlled not to exceed 0.2 mm.

[0074] The conductive disc **202** can be a substantially flat, arched, domed or concave pressure sensitive element that flexes or deflects when a force is applied to the conductive disc **202**. In operation when the cell **200** is placed within an electronic device for powering, the battery compartment or electrode of the electronic device applies a force on the conductive disc **202** thereby flexing, deflecting or biasing the conductive disc **202** to electrically engage or contact the anode **204** of the cell **200**. This is termed the active state or configuration of the cell **200** when the conductive disc **202** electrically engages or contacts the anode **204** and voltage is produced. When the cell **200** is removed from the electronic device the force upon the conductive disc **202** is released and the conductive disc deflects away from the anode **204**, allowing the adhesive insulator **206** layer to separate the conductive disc **202** from the anode **204**. This is termed the inactive state or configuration of the cell **200** and the conductive disc **202** is separated from electrical engagement or contact with the anode **204** when the cell **200** is not in use. Therefore, if a victim orally contacts or ingests the button cell safety system **200**, the cell **200** remains in the inactive state to prevent or mitigate harm to the victim caused by an active battery.

[0075] FIGS. **3**A-**3**B illustrate a cross-sectional schematic of an exemplary button cell safety system **300** according to another embodiment. FIG. **3**A illustrates a cross-sectional view of the entire button cell assembly **300**, and FIG. **3**B illustrates a close-up, cross-sectional view of a portion of the button cell assembly **300**. The button cell **300** includes a pressure sensitive conductive disc **302**, an anode **304**, an adhesive insulator **306**, a mitigating composition **308**, a sealing compound **310**, an insulator ring **312** and a cathode **314** that make up different layers of the cell assembly **300**.

[0076] The cathode **314** can make up the outer shell of the button cell **300**. The anode **304** disc or plate and/or the insulator ring **312** can be at least partially disposed within the cathode shell **314**. The anode **304**, cathode **314** and conductive disc **302** can be positioned to abut or engage a surface or cavity within the insulator ring **312**. The insulator ring **312** separates the anode **304** from the cathode **314** within the cell **300**, forms a layer of insulation and prevents conductive contact between the anode **304** and cathode **314**. The insulator ring **312** can also facilitate separation of the conductive disc **302** from contact with the anode **304** when the cell **300** is not in use. The shape and size of the conductive disc **302**, the anode **304**, the cathode **314**, the insulator ring **306** and cavities within the insulator ring can be modified to achieve a certain degree of separation between all conductive elements **302**, **304**, **314**.

[0077] The conductive disc **302** is a conductive element positioned on top of an adhesive insulator **306** layer, which separates the conductive disc **302** from the anode **304** and prevents conductive contact between the conductive disc **302** and the anode **304** when the cell **300** is not in use. In an exemplary embodiment, the adhesive insulator **306** layer separates the conductive disc **302** from the anode **304** by less than 1 mm of clearance. The adhesive insulator **306** layer can be applied first on top of a slanted surface of the anode **304** before the conductive disc **302** is adhesively applied on top of the adhesive insulator **306** layer by applying pressure to promote firm adhesion between layers. The adhesive insulator **306** can also be applied to the conductive disc **302** first before the combined assembly is attached to a slanted surface of the anode **304** by applying pressure to promote firm adhesion between layers.

[0078] A sealing compound **310** can be applied on at least a portion of the conductive disc **302**, the exposed portion of the anode **304** and/or a portion of the cathode **314** to form a water tight seal. The sealing compound **310** can be applied on a portion of the conductive disc **302**, leaving at least a portion of the conductive disc **302** uncovered and exposed for electrical contact. The anode **304** is completely contained and sealed within the cell **300**.

[0079] A mitigating composition **308** can be applied on at least a portion of the cathode **314**, the sealing compound **310** and/or and the conductive disc **302**. The mitigating composition **308** can be applied on a portion of the conductive disc **302**, leaving at least a portion of the conductive disc **302** uncovered and exposed for electrical contact. An exemplary mitigating composition **308** can be applied to any surface of the button cell **300** to prevent or mitigate harmful effects caused by oral contact or ingestion of a button cell **300**. As disclosed herein, the mitigating composition **308** can include an aversive agent component, a colorant component, a salivating agent component, an emetic component or mixtures thereof. A multi-component mitigating composition **308** can provide any combination of the following functionalities: (1) the colorant and salivating components can provide visual indication of ingestion or oral contact; (2) the aversive agent component can prevent or deter ingestion or oral contact; and (3) the emetic component can reverse ingestion by causing the victim to vomit.

[0080] The cell **300** can be placed in a warm environment or oven to dry the various layers during or after assembly of the cell **300**. Dimensional increase caused by drying the adhesive insulator **306** layer and sealing compound **310** can be controlled not to exceed 0.3 mm. Dimensional increase caused by drying the mitigating composition **308** can be controlled not to exceed 0.2 mm.

[0081] The conductive disc **302** can be a substantially flat, arched, domed or concave pressure sensitive element that flexes or deflects when a force is applied to the conductive disc **302**. In operation when the cell **300** is placed within an electronic device for powering, the battery compartment or electrode of the electronic device applies a force on the conductive disc **302** thereby flexing, deflecting or biasing the conductive disc **302** to electrically engage or contact the anode **304** of the cell **300**. This is termed the active state or configuration of the cell **300** when the conductive disc **302** electrically engages or contacts the anode **304** and voltage is produced. When the cell **300** is removed from the electronic device, the force upon the conductive disc **302** is released and the conductive disc deflects away from the anode **304**, allowing the adhesive insulator **306** layer to separate the conductive disc **302** from the anode **304**. This is termed the inactive state or configuration of the cell **300** and the conductive disc **302** is separated from electrical engagement or contact with the anode **304** when the cell **300** is not in use. Therefore, if a victim orally contacts or ingests the button cell safety system **300**, the cell remains in the inactive state to prevent or mitigate harm to the victim caused by an active battery.

[0082] FIGS. **4**A-**4**B illustrate a cross-sectional schematic of an exemplary button cell safety system **400** according to another embodiment. FIG. **4**A illustrates a cross-sectional view of the entire button cell assembly **400**, and FIG. **4**B illustrates a close-up, cross-sectional view of a portion of the button cell assembly **400**. The button cell **400** includes a pressure sensitive conductive disc **402**, an anode **404**, an adhesive insulator **406**, a mitigating composition **408**, an insulator ring **412** and a cathode **414** that make up different layers of the cell assembly **400**.

[0083] The cathode **414** can make up the outer shell of the button cell **400**. The anode **404** disc or plate and/or the insulator ring **412** can be at least partially disposed within the cathode shell **414**. The anode **404**, cathode **414** and conductive disc **402** can be positioned to abut or engage a surface or cavity within the insulator ring **412**. The insulator ring **412** separates the anode **404** from the cathode **414** within the cell **400**, forms a layer of insulation and prevents conductive contact between the anode **404** and cathode **414**. The insulator ring **412** can also facilitate separation of the conductive disc **402** from conductive contact with the anode **404** when the cell **400** is not in use. The shape and size of the conductive disc **402**, the anode **404**, the cathode **414**, the insulator ring **406** and cavities within the insulator ring **406** can be modified to achieve a certain degree of separation between all conductive elements **402**, **404**, **414**. The conductive disc **402** spans the entire exposed surface of the anode **404**, seals the cell **400** and contains the anode **404** entirely within the cell **400**.

[0084] The conductive disc **402** is a conductive element positioned on top of an adhesive insulator **406** layer, which separates the conductive disc **402** from the anode **404** and prevents conductive contact between the conductive disc **402** and the anode **404** when the cell **400** is not in use. In an exemplary embodiment, the adhesive insulator **406** layer separates the conductive disc **402** from the anode **404** by less than 1 mm of clearance. The adhesive insulator **406** layer can be applied first on top of a slanted surface of the anode **404** before the conductive disc **402** is adhesively applied on top of the adhesive insulator **406** layer by applying pressure to promote firm adhesion between layers. The adhesive insulator **406** can also be applied to the conductive disc **402** first before the combined assembly is attached to a slanted surface of the anode **404** by applying pressure to promote firm adhesion between layers.

[0085] A mitigating composition **408** can be applied on at least a portion of the cathode **414**, the conductive disc **402** and/or the insulator ring **412**. The mitigating composition **408** can be applied on a portion of the conductive disc **402** leaving at least a portion of the conductive disc **402** uncovered and exposed for electrical contact. An exemplary mitigating composition **408** can be applied to any surface of the button cell **400** to prevent or mitigate harmful effects caused by oral contact or ingestion of a button cell **400**. As disclosed herein, the mitigating composition **408** can include an aversive agent component, a colorant component, a salivating agent component, an emetic component or mixtures thereof. A multi-component mitigating composition **408** can provide any combination of the following functionalities: (1) the colorant and salivating components can provide visual indication of ingestion or oral contact; (2) the aversive agent component can prevent or deter ingestion or oral contact; and (3) the emetic component can reverse ingestion by causing the victim to vomit.

[0086] The cell **400** can be placed in a warm environment or oven to dry the various layers during and after assembly of the cell **400**. Dimensional increase caused by drying the mitigating composition **408** can be controlled not to exceed 0.2 mm.

[0087] The conductive disc **402** can be a substantially flat, arched, domed or concave pressure sensitive element that flexes or deflects when a force is applied to the conductive disc **402**. In operation when the cell **400** is placed within an electronic device for powering, the battery compartment or electrode of the electronic device applies a force on the conductive disc **402** thereby flexing, deflecting or biasing the conductive disc **402** to electrically engage or contact the anode **404** of the cell **400**. This is termed the active state or configuration of the cell **400** when the conductive disc **402** electrically engages or contacts the anode **404** and voltage is produced. When the cell **400** is removed from the electronic device the force upon the conductive disc **402** is released and the conductive disc deflects away from the anode **404**, allowing the adhesive insulator **406** layer to separate the conductive disc **402** from the anode **404**. This is termed the inactive state or configuration of the cell **400** and the conductive disc **402** is separated from electrical engagement or contact with the anode **404** when the cell **400** is not in use. Therefore, if a victim orally contacts or ingests the button cell safety system **400**, the cell remains in the inactive state to prevent or mitigate harm to the victim caused by an active battery.

[0088] FIGS. **5**A-**5**B illustrate a cross-sectional schematic of an exemplary button cell safety system **500** according to another embodiment. FIG. **5**A illustrates a cross-sectional view of the entire button cell assembly **500**, and FIG. **5**B illustrates a close-up, cross-sectional view of a portion of the button cell assembly **500**. The button cell **500** includes a pressure sensitive conductive disc **502**, an anode **504**, a mitigating composition **508**, an insulator ring **512** and a cathode **514** that make up different layers of the cell assembly **500**.

[0089] The cathode **514** can make up the outer shell of the button cell **500**. The anode **504** disc or plate and/or the insulator ring **512** can be at least partially disposed within the cathode shell **514**. The anode **504**, cathode **514** and conductive disc **502** can be positioned to abut or engage a surface or cavity within the insulator ring **512**. The insulator ring **512** separates the anode **504** from the cathode **514** within the cell **500**, forms a layer of insulation and prevents conductive contact between the anode **504** and cathode **514**. The conductive disc **502** and the anode **504** can be inserted into a cavity within the insulator ring **512** prior to assembly or incorporation with other components of the cell **500**. The insulator ring **512** facilitates separation of the conductive disc **502** from conductive contact with the anode **504** when the cell **500** is not in use.

[0090] The shape and size of the conductive disc **502**, the anode **504**, the cathode **514**, the insulator ring **506** and cavities within the insulator ring **506** can be modified to achieve a certain degree of separation between all conductive elements **502**, **504**, **514**. The conductive disc **502** spans the entire exposed surface of the anode **504**, seals the cell **500** and contains the anode **504** entirely within the cell **500**. In an exemplary embodiment, the distance between the conductive disc **502** and the anode **504** is less than 1 mm.

[0091] A mitigating composition **508** can be applied on at least a portion of the cathode **514**, the conductive disc **502** and/or the insulator ring **512**. The mitigating composition **508** can be applied on a portion of the conductive disc **502** leaving at least a portion of the conductive disc **502** uncovered and exposed for electrical contact. An exemplary mitigating composition **508** can be applied to any surface of the button cell **500** to prevent or mitigate harmful effects caused by oral contact or ingestion of a button cell **500**. As disclosed herein, the mitigating composition **508** can include an aversive agent component, a colorant component, a salivating agent component, an emetic component or mixtures thereof. A multi-component mitigating composition **508** can provide any combination of the following functionalities: (1) the colorant and salivating components can provide visual indication of ingestion or oral contact; (2) the aversive agent component can prevent or deter ingestion or oral contact; and (3) the emetic component can reverse ingestion by causing the victim to vomit.

[0092] The cell **500** can be placed in a warm environment or oven to dry the various layers during and after assembly of the cell **500**. Dimensional increase caused by drying the mitigating composition **508** can be controlled not to exceed 0.2 mm.

[0093] The conductive disc **502** can be a substantially flat, arched, domed or concave pressure sensitive element that flexes or deflects when a force is applied to the conductive disc **502**. In operation when the cell **500** is placed within an electronic device for powering, the battery compartment or electrode of the electronic device applies a force on the conductive disc **502** thereby flexing, deflecting or biasing the conductive disc **502** to electrically engage or contact the anode **504** of the cell **500**. This is termed the active state or configuration of the cell **500** when the conductive disc **502** electrically engages or contacts the anode **504** and voltage is produced. When the cell **500** is removed from the electronic device, the force upon the conductive disc **502** is released and the conductive disc deflects away from the anode **504**, separating the conductive disc **502** from conductive contact with the anode **504**. This is termed the inactive state or configuration of the cell **500** and the conductive disc **502** is separated from electrical engagement or contact with the anode **504** when the cell **500** is not in use. Therefore, if a victim orally contacts or ingests the button cell safety system **500**, the cell remains in the inactive state to prevent or mitigate harm to the victim caused by an active battery.

[0094] FIGS. **6**A-**6**B illustrate a cross-sectional schematic of an exemplary button cell safety system **600** according to another embodiment. FIG. **6**A illustrates a cross-sectional view of the entire button cell assembly **600**, and FIG. **6**B illustrates a close-up, cross-sectional view of a portion of the button cell assembly **600**. The button cell **600** includes a pressure sensitive conductive disc **602**, an anode **604**, a mitigating composition **608**, an upper insulator ring **612***a*, a lower insulator ring **612***b* and a cathode **614** that make up different layers of the cell assembly.

[0095] The cathode **614** can make up the outer shell of the button cell **600**. The anode **604** disc or plate and/or the insulator rings **612***a*, **612***b* can be at least partially disposed within the cathode shell **614**. The anode **604** is inserted to engage a cavity within the lower insulator ring **612***b*. The cathode **614** and conductive disc **602** can be inserted to engage cavity within the upper insulator ring **612***a*. The upper insulator ring **612***a* and lower insulator ring **612***b* separates the anode **604** from the cathode **614** within the cell **600**, forms a layer of insulation and prevents conductive contact between the anode **604** and cathode **614**. The conductive disc **602** can be inserted into a cavity within the upper insulator ring **612***a* prior to assembly or incorporation with other components of the cell **600**. The anode **604** can also be inserted into a cavity within the lower insulator ring **612***b* prior to assembly or incorporation with other components of the cell **600**. Insertion into the upper insulator ring **612***a* and lower insulator ring **612***b* facilitates separation of the conductive disc **602** from conductive contact with the anode **604** when the cell **600** is not in use.

[0096] The shape and size of the conductive disc **602**, the anode **604**, the cathode **614**, the upper insulator ring **612***a*, the lower insulator ring **612***b* and cavities within the insulator rings can be modified to achieve a certain degree of separation between all conductive elements **602**, **604**, **614**. The conductive disc **602** spans the entire exposed surface of the anode **604**, seals the cell **600** and contains the anode **604** entirely within the cell **600**. In an exemplary embodiment, the distance between the conductive disc **602** and the anode **604** is maintained at less than 1 mm.

[0097] A mitigating composition **608** can be applied on at least a portion of the cathode **614**, the conductive disc **602** and/or the upper insulator ring **612***a*. The mitigating composition **608** can be applied on a portion of the conductive disc **602** leaving at least a portion of the conductive disc **602** uncovered and exposed for electrical contact. An exemplary mitigating composition **608** can be applied to any surface of the button cell **600** to prevent or mitigate harmful effects caused by oral contact or ingestion of a button cell **600**. As disclosed herein, the mitigating composition **608** can include an aversive agent component, a colorant component, a salivating agent component, an emetic component or mixtures thereof. A multi-component mitigating composition **608** can provide any combination of the following functionalities: (1) the colorant and salivating components can provide visual indication of ingestion or oral contact; (2) the aversive agent component can prevent or deter ingestion or oral contact; and (3) the emetic component can reverse ingestion by causing the victim to vomit.

[0098] The cell **600** can be placed in a warm environment or oven to dry the various layers during and after assembly of the cell **600**. Dimensional increase caused by drying the mitigating composition **608** can be controlled not to exceed 0.2 mm.

[0099] The conductive disc **602** can be a substantially flat, arched, domed or concave pressure sensitive element that flexes or deflects when a force is applied to the conductive disc **602**. In operation when the cell **600** is placed within an electronic device for powering, the battery compartment or electrode of the electronic device applies a force on the conductive disc **602** thereby flexing, deflecting or biasing the conductive disc **602** to electrically engage or contact the anode **604** of the cell **600**. This is termed the active state or configuration of the cell **600** when the conductive disc **602** electrically engages or contacts the anode **604** and voltage is produced. When the cell **600** is removed from the electronic device, the force upon the conductive disc **602** is released and the conductive disc deflects away from the anode **604**, separating the conductive disc **602** from conductive contact with the anode **604**. This is termed the inactive state or configuration of the cell **600** and the conductive disc **602** is separated from electrical engagement or contact with the anode **604** when the cell **600** is not in use. Therefore, if a victim orally contacts or ingests the button cell safety system **600**, the cell remains in the inactive state to prevent or mitigate harm to the victim caused by an active battery.

[0100] FIGS. **7**A-**7**B illustrate a cross-sectional schematic of an exemplary button cell safety system **700** according to another embodiment. FIG. **7**A illustrates a cross-sectional view of the entire button cell assembly **700**, and FIG. **7**B illustrates a close-up, cross-sectional view of a portion of the button cell assembly **700**. The button cell **700** includes a pressure sensitive conductive disc **702**, an anode **704**, a mitigating composition **708** integrated into a portion of the insulator ring **712** and a cathode **714** that make up different layers of the cell assembly **700**.

[0101] The cathode **714** can make up the outer shell of the button cell **700**. The anode **704** disc or plate and/or the insulator ring **712** can be at least partially disposed within the cathode shell **714**. The anode **704**, cathode **714** and conductive disc **702** can be positioned to abut or engage a surface or cavity within the insulator ring **712**. The insulator ring **712** separates the anode **704** from the cathode **714** within the cell **700**, forms a layer of insulation and prevents conductive contact between the anode **704** and cathode **714**. The conductive disc **702** and the anode **704** can be inserted into a cavity within the insulator ring **712** prior to assembly or incorporation with other components of the cell **700**. In this embodiment, the conductive disc **702** is inserted into a cavity within the portion of the insulator ring **712** integrated with the migrating composition **708**. The insulator ring **712** facilitates separation of the conductive disc **702** from conductive contact with the anode **704** when the cell **700** is not in use.

[0102] The shape and size of the conductive disc **702**, the anode **704**, the cathode **714**, the insulator ring **706** and cavities within the insulator ring **706** can be modified to achieve a certain degree of separation between all conductive elements **702**, **704**, **714**. The conductive disc **702** spans the entire exposed surface of the anode **704**, seals the cell **700** and contains the anode **704** entirely within the cell **700**. In an exemplary embodiment, the distance between the conductive disc **702** and the anode **704** is less than 1 mm.

[0103] At least a portion of the insulator ring **712** can be integrated with a mitigating composition **708** during processing to form an integral piece. As disclosed herein, the mitigating composition **708** can include an aversive agent component, a colorant component, a salivating agent component, an emetic component or mixtures thereof. A multi-component mitigating composition **708** can provide any combination of the following functionalities: (1) the colorant and salivating components can provide visual indication of ingestion or oral contact; (2) the aversive agent component can prevent or deter ingestion or oral contact; and (3) the emetic component can reverse ingestion by causing the victim to vomit.

[0104] The cell **700** or component parts thereof can be placed in a warm environment or oven to dry the various layers during and after assembly of the cell **700**. Dimensional increase caused by drying the mitigating composition **708** during integration with the insulator ring **712** can be controlled not to exceed 0.2 mm.

[0105] The conductive disc **702** can be a substantially flat, arched, domed or concave pressure sensitive element that flexes or deflects when a force is applied to the conductive disc **702**. In operation when the cell **700** is placed within an electronic device for powering, the battery compartment or electrode of the electronic device applies a force on the conductive disc **702** thereby flexing, deflecting or biasing the conductive disc **702** to electrically engage or contact the anode **704** of the cell **700**. This is termed the active state or configuration of the cell **700** when the conductive disc **702** electrically engages or contacts the anode **704** and voltage is produced. When the cell **700** is removed from the electronic device, the force upon the conductive disc **702** is released and the conductive disc deflects away from the anode **704**, separating the conductive disc **702** from conductive contact with the anode **704**. This is termed the inactive state or configuration of the cell **700** and the conductive disc **702** is separated from electrical engagement or contact with the anode **704** when the cell **700** is not in use. Therefore, if a victim orally contacts or ingests the button cell safety system **700**, the cell remains in the inactive state to prevent or mitigate harm to the victim caused by an active battery.

[0106] FIGS. **8**A-**8**B illustrate a cross-sectional schematic of an exemplary button cell safety system **800** according to another embodiment. FIG. **8**A illustrates a cross-sectional view of the entire button cell assembly **800**, and FIG. **8**B illustrates a close-up, cross-sectional view of a portion of the button cell assembly **800**. The button cell **800** includes a pressure sensitive conductive disc **802**, an anode **804**, a mitigating composition **808** integrated into the entire insulator ring **812** and a cathode **814** that make up different layers of the cell assembly **800**.

[0107] The cathode **814** can make up the outer shell of the button cell **800**. The anode **804** disc or plate and/or the insulator ring **812** can be at least partially disposed within the cathode shell **814**. The anode **804**, cathode **814** and conductive disc **802** can be positioned to abut or engage a surface or cavity within the insulator ring **812** integrated with mitigation composition **808**. The insulator ring **812** separates the anode **804** from the cathode **814** within the cell **800**, forms a layer of insulation and prevents conductive contact between the anode **804** and cathode **814**. The conductive disc **802** and the anode **804** can be inserted into a cavity within the insulator ring **812** prior to assembly or incorporation with other components of the cell **800**. The insulator ring **812** facilitates separation of the conductive disc **802** from conductive contact with the anode **804** when the cell **800** is not in use.

[0108] The shape and size of the conductive disc **802**, the anode **804**, the cathode **814**, the insulator ring **806** and cavities within the insulator ring **806** can be modified to achieve a certain degree of separation between all conductive elements **802**, **804**, **814**. The conductive disc **802** spans the entire exposed surface of the anode **804**, seals the cell **800** and contains the anode **804** entirely within the cell **800**. In an exemplary embodiment, the distance between the conductive disc **802** and the anode **804** is less than 1 mm.

[0109] At least a portion of the insulator ring **812** can be integrated with a mitigating composition **808** during processing to form an integral piece. In this embodiment, the entire insulator ring **812** is integrated with the migrating composition **808**. As disclosed herein, the mitigating composition **808** can include an aversive agent component, a colorant component, a salivating agent component, an emetic component or mixtures thereof. A multi-component mitigating composition **808** can provide any combination of the following functionalities: (1) the colorant and salivating components can provide visual indication of ingestion or oral contact; (2) the aversive agent component can prevent or deter ingestion or oral contact; and (3) the emetic component can reverse ingestion by causing the victim to vomit.

[0110] The cell **800** or component parts thereof can be placed in a warm environment or oven to dry the various layers during and after assembly of the cell **800**. Dimensional increase caused by drying the mitigating composition **808** during integration with the insulator ring **812** can be controlled not to exceed 0.2 mm.

[0111] The conductive disc **802** can be a substantially flat, arched, domed or concave pressure sensitive element that flexes or deflects when a force is applied to the conductive disc **802**. In operation when the cell **800** is placed within an electronic device for powering, the battery compartment or electrode of the electronic device applies a force on the conductive disc **802** thereby flexing, deflecting or biasing the conductive disc **802** to electrically engage or contact the anode **804** of the cell **800**. This is termed the active state or configuration of the cell **800** when the conductive disc **802** electrically engages or contacts the anode **804** and voltage is produced. When the cell **800** is removed from the electronic device, the force upon the conductive disc **802** is released and the conductive disc deflects away from the anode **804**, separating the conductive disc **802** from conductive contact with the anode **804**. This is termed the inactive state or configuration of the cell **800** and the conductive disc **802** is separated from electrical engagement or contact with the anode **804** when the cell **800** is not in use. Therefore, if a victim orally contacts or ingests the button cell safety system **800**, the cell remains in the inactive state to prevent or mitigate harm to the victim caused by an active battery.

Conductive Disc

[0112] In an exemplary embodiment, the conductive discs herein disclosed is a circular piece of metal cut from a metal sheet having a thickness of less than 0.5 mm. Many different metals can be used to construct the conductive disc including, but not limited to the following: (1) stainless steel type: 301, 302, 304, 309, 316 or 321; hardness: Rockwell B88, C28-C38 or C40-C45; (2) brass type: 260 or 464; hardness: Rockwell 30T 56-74; (3) copper type: 110 or 122; hardness: Rockwell 15T 47-57. Conductive discs were cut between 14-22 mm in diameter.

[0113] One or more of the following steps can be used to construct the conductive discs herein disclosed. In step **1**, burrs, rough edges and uneven surfaces are carefully removed and flattened from the cut piece. In step **2**, marginal area of the piece is smoothly bent along its circumference to form a dish that fits the profile of anode of button cell. In step **3**, a central part of the piece is embossed to form an obtuse dome (diameter: less than 19 mm, height: less than 2 mm). In step **4**, for sure electric contacts, multiple small bumps (diameter: less than 10 mm, height: less than 2 mm) were embossed, preferably forming an orderly shape having radial symmetry. Finished conductive disks were thoroughly inspected and cleaned using isopropyl alcohol. Any unevenness along the circumference was removed.

[0114] In an exemplary embodiment, the conductive disk is constructed to have a restoring force in the range of 5 g/cm^2 (490 N/m^2) to 200 g/cm^2 (19,613 N/m^2). The resilience of the conductive disk maintains the button cell in a default deactivated state even under pressures and forces applied by a victims, mouth, esophagus, stomach or digestive tract.

[0115] FIGS. **2**A-**2**B depict an example of a conductive disk prepared using step **1**, step **3** and step **4**. FIGS. **3**A-**3**B depict an example of a conductive disk prepared using step **1**, step **2**, step **3** and step **4**. FIGS. **4**A-**4**B, **5**A-**5**B, **6**A-**6**B and **7**A-**7**B depict examples of conductive disks prepared using step **1** and step **2**. FIGS. **8**A-**8**B depict an example of a conductive disk prepared using step **1**, step **2** and step **3**.

Sealing Compound

[0116] In an exemplary embodiment, the sealing compounds herein disclosed can be made of base resin containing 30 g clear ABS and 12 g of PMMA introduced into a solvent mixture of 200 ml of acetone, 180 ml of methylene chloride and 20 ml of 2-butoxyethanol. The mixture was heated to 45° C. and stirred until a viscous homogeneous solution was formed. 2 g of plasticizer containing 1,2-cyclohexanedicarboxylic acid diisononyl ester, 2 g of glyceryl hydrogenated rosinate and a stabilizer containing 0.02 g of 2,2-methylene-bis(6-(2H-benzotriazol-2-yl)-4-(1,1,3,3-tetramethylbutyl) phenol were added into the solution and mixed well. The sealing compound is not limited to the above formulation and can be made from any noncorrosive, nonconductive, water proof and/or other material capable of creating an air and moisture tight seal.

Adhesive Insulator

[0117] The exemplary adhesive insulators herein disclosed can be ring-shaped adhesive insulators (outside diameter: less than 20 mm, inside diameter: less than 19 mm) cut from double-sided tape strands using a stamping press or a laser cutter. The adhesive insulator must have a sufficient volume resistivity (p) higher than $1.0e^3$ Ω·m when measured at 20° C. in order to provide proper insulation between anode and cathode and have an appropriate thickness between 0.01 and 0.20 mm in order to physically separate the conductive disk from anode of a button cell assembly.

[0118] Alternatively, chemical compounds that contain adhesive materials can be used. If the compound is liquid and composed of solvent(s) and solute(s), its composition may need to be differentiated from that of sealing compounds herein disclosed in order to prevent possible erosion. The proticity and/or polarity of solutions used to make the sealing composition and adhesive insulator can be varied to prevent erosion.

[0119] The pressure sensitive tape used to construct the adhesive insulator can be acrylic or rubber-based adhesive applied on the both sides of a polymer carrier ("double-coated") or with no carrier material ("adhesive transfer"). An adhesive compound such as phenolic resin, polyurethane, polyester, nitrocellulose and/or alkyd can also be mixed with solvents including ethyl acetate, methyl ethyl ketone, butyl acetate and/or butyl alcohol to form a solution used to form adhesive tape or to apply on a carrier to make the adhesive insulator.

Insulator Ring

[0120] An exemplary insulator ring herein disclosed can be constructed with material to insulate the anode from electrical contact with the cathode. The insulator ring can be seated around a cathode cup in the button cell. The insulator ring separates the two poles and seals a battery by holding brims of both a cathode cup and an anode disk.

Insulator Ring with Integrated Colorant Composition

[0121] An insulator ring can be integrally formed with the mitigating compositions herein disclosed. An in exemplary embodiment, colorant was melt-blended with a commercially available polypropylene resin for 10 minutes at 180° C. using a mixer or a twin-screw extruder until the components reach a completely homogenized state. Addition of a heat stabilizing system to the mixture for blending may be necessary to protect the component parts from decomposition. Other polymers such as LDPE or modified polyolefin can also be used in place of or together with polypropylene in order to lower the processing temperature and improve the overall compatibility of the colorant composition with the insulator ring. The polymer blend is then injection molded to make an insulator ring integrated with a colorant composition.

[0122] FIGS. **7**A-**7**B depict an exemplary color compound-integrated insulator ring with a conductive disc cavity in the integrated portion of the insulator ring and an anode cavity in the non-integrated portion of the insulator ring. FIGS. **8**A-**8**B depict color compound-integrated insulator ring with a cavity for the anode and conductive disc in the integrated portion of the insulator ring.

Button Cell Pressure Sensitive Testing

[0123] Exemplary button cell safety systems were inserted into several electronic devices to test durability of the pressure sensitive conductive disk. First, exemplary button cell safety systems were positioned in a battery compartment of electronic devices and then quickly extracted for insertion into a next device. The cell was inserted into three devices with different compartment structures (spring-supported, two in a series, and slot-in) to complete one cycle, and the entire test was composed of 20 cycles. After the test, a 100 g of weight with insulated surfaces was put on the conductive disk of the battery and left for 5 days to check long-term durability of the pressure sensitiveness feature. Four batteries were prepared and tested (the even number was selected due to the "two in a series" device), and all specimens passed both the repeated insertions and durability tests.

Button Cell Immersion Testing

[0124] An exemplary button cell safety system and an untreated button battery were immersed in 150 ml of artificial saliva separately, prepared in accordance with the composition outlined in Table 3 provided below.

TABLE 3

Composition of Artificial Saliva

Reagents	Mass fraction (g/l)
Magnesium chloride ($MgCl_2 \cdot 6H_2O$)	0.17
Calcium chloride ($CaCl_2 \cdot 2H_2O$)	0.15
Dipotassium hydrogen phosphate ($K_2HPO_4 \cdot 3H_2O$)	0.76
Potassium carbonate (K_2CO_3)	0.53
Sodium chloride (NaCl)	0.33
Potassium chloride (KCl)	0.75

1% (m/m) Hydrochloric acid was added until a pH value of 6.8 ± 0.1 was achieved.

[0125] As illustrated in FIG. **9**, the untreated battery **902** started bubbling just after the immersion in artificial saliva and was seriously corroded within an hour, while the exemplary button cell safety system **904** remained inactive in the solution for 8 hours until the test ended. As illustrated in FIG. **10**, the pH of the artificial salvia increased significantly with time when the active, untreated battery was immersed. The pH of the artificial salvia did not increase with time when the inactive, treated battery was immersed.

[0126] Exemplary button cells remain inactive while not in use. When the button cell is inserted into a device, a certain magnitude of pressure is applied to the conductive disk to create conductive contact with the anode. Therefore, the button cell only releases charge when in use in a proper device to prevent an active cell from being swallowed.

[0127] New CR2032 batteries produce over 3 volts of power and even a "dead" battery can generate 2 volts of power, which is enough to put the victim in danger. A swallowed battery can stick to the inner surface of alimentary canal, such as esophagus or stomach, and can make perforations which may cause several serious permanent symptoms and even death. With the pressure sensitiveness feature, the exemplary button cell safety systems herein disclosed remain inactive and inert without causing any injuries even when ingested.

[0128] Furthermore, the mitigating compositions herein disclosed can include an aversive agent component, a colorant component, a salivating agent component, an emetic component or mixtures thereof applied to one or more surfaces of the button cell. A multi-component mitigating composition can provide any combination of the following functionalities: (1) the colorant and salivating components can provide visual indication of ingestion or oral contact; (2) the aversive agent component can prevent or deter ingestion or oral contact; and (3) the emetic component can reverse ingestion by causing the victim to vomit.

[0129] Example embodiments have been described hereinabove regarding improved systems, methods and composition for preventing and mitigating ingestion of harmful materials. Various modifications to and departures from the disclosed example embodiments will occur to those having ordinary skill in the art. The subject matter that is intended to be within the spirit of this disclosure is set forth in the following claims.

What is claimed is:

1. A button cell comprising:

a cathode shell;

an insulator ring comprising an anode cavity at least partially positioned within the cathode shell;

an anode plate engaging the anode cavity in the insulator ring; and

a pressure sensitive conductive disc configured for actuation between a default inactive cell state and an active cell state.

2. The button cell recited in claim **1**, wherein the pressure sensitive conductive disc is positioned a maximum clearance distance above the anode in the default inactive cell state.

3. The button cell recited in claim **1**, wherein the pressure sensitive conductive disc is configured to conductively contact the anode in the active cell state.

4. The button cell recited in claim **3**, wherein the pressure sensitive conductive disc is configured to conductively contact the anode in the active cell state by application of a compressive force against the conductive disc.

5. The button cell recited in claim **4**, wherein the pressure sensitive conductive disc is configured to automatically return to the default inactive cell state in response to releasing the compressive force against the conductive disc.

6. The button cell recited in claim **1**, further comprising a mitigating composition applied on a surface of at least one of the anode plate, cathode shell and conductive disc.

7. The button cell recited in claim **6**, wherein the mitigating composition comprises at least one component selected from group consisting of: an aversive agent component, a colorant component, a salivating agent component and an emetic component.

8. The button cell recited in claim **1**, wherein the insulator ring further comprises a conductive disc cavity and the pressure sensitive conductive disc engages the conductive disc cavity in the insulator ring.

9. The button cell recited in claim **2**, further comprising an adhesive insulator positioned between the pressure sensitive conductive disc and the anode plate to maintain the maximum clearance distance between the pressure sensitive conductive disc and the anode plate in the default inactive cell state.

10. The button cell recited in claim **1**, further comprising a sealing compound applied on a top exposed surface of at least one of the anode plate, cathode shell and conductive disc to create an upper sealing layer.

11. The button cell recited in claim **10**, wherein the upper sealing layer is a water tight seal.

12. The button cell recited in claim **11**, further comprising a mitigating composition applied on a surface of at least one of the anode plate, cathode shell, pressure sensitive conductive disc and upper sealing layer.

13. The button cell recited in claim **12**, wherein the mitigating composition comprises at least one component selected from group consisting of: an aversive agent component, a colorant component, a salivating agent component and an emetic component.

14. The button cell recited in claim **1**, wherein the insulator ring is integrated with a mitigating composition.

15. The button cell recited in claim **1**, wherein the mitigating composition is a colorant composition comprising black edible activated carbon.

16. The button cell recited in claim **1**, wherein the insulator ring comprises a lower insulator portion and an upper insulator portion.

17. The button cell recited in claim **16**, wherein the upper insulator portion is integrated with a mitigating composition.

18. The button cell recited in claim **17**, wherein the mitigating composition is a colorant composition comprising black edible activated carbon.

19. The button cell recited in claim **17**, wherein the anode plate is located within the lower insulator portion and conductive disc cavity is located within the upper insulator portion.

20. The button cell recited in claim **1**, wherein the pressure sensitive conductive disk is a substantially flat disc of metal or a domed disc of metal.

21. The button cell recited in claim **20**, wherein the pressure sensitive conductive disc is formed from at least one component selected from the group consisting of: stainless steel, brass and copper.

22. The button cell recited in claim **2**, wherein the maximum clearance distance is 1 mm.

* * * * *