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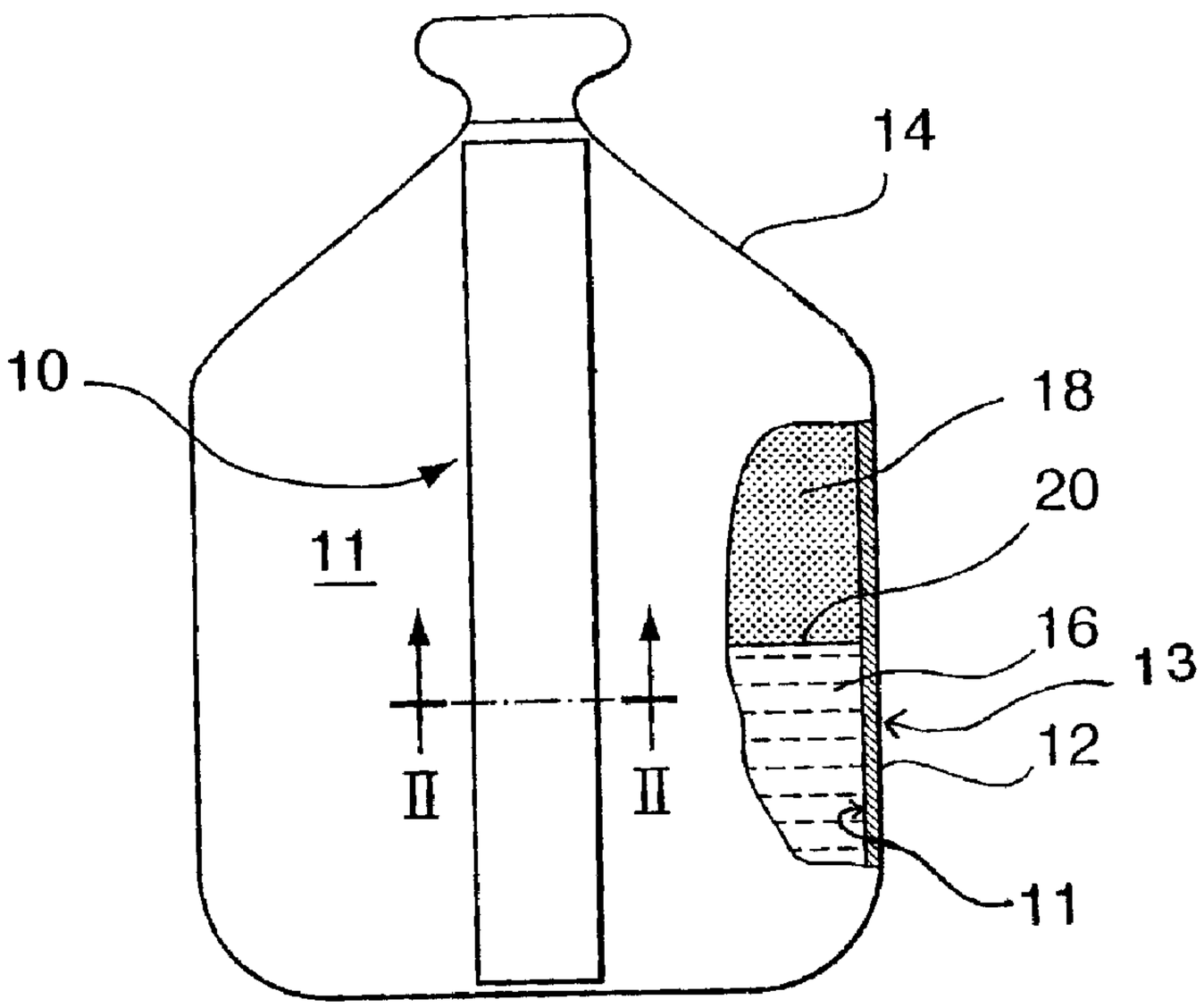
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(54) Titre : JAUGE THERMOCHROMATIQUE DU NIVEAU DE LIQUIDE, A APPLICATION EXTERNE DIRECTE, ET METHODE CONNEXE

(54) Title: DIRECTLY APPLIED THERMOCROMATIC EXTERNAL LIQUID LEVEL GAUGE AND METHOD



(57) Abrégé/Abstract:
A thermochromatic external liquid level gauge and method is provided which is directly applied to the outside surface of the outside wall of a container, for use in the determination of the level of the interface between a mass of flowable material and the void volume above it within a container. The thermochromatic external liquid level gauge vertically extends along substantially the entire length of the container. It comprises at least two thermochromatic materials which are directly applied to the outside wall by such application methods as painting, silk screening, stencilling, molding, crayon transfer, pencil transfer, screening, and combinations thereof. Each of the thermochromatic materials responds chromatically within a different operating temperature range. In an alternative embodiment, the thermochromatic external liquid level gauge further includes a substrate having a series of indicia printed thereon, in which the substrate is directly applied to the outside surface of the outside wall of the container.

ABSTRACT OF THE DISCLOSURE:

A thermochromatic external liquid level gauge and method is provided which is directly applied to the outside surface of the outside wall of a container, for use in the determination of the level of the interface between a mass of flowable material and the void volume above it within a container. The thermochromatic external liquid level gauge vertically extends along substantially the entire length of the container. It comprises at least two thermochromatic materials which are directly applied to the outside wall by such application methods as painting, silk screening, stencilling, molding, crayon transfer, pencil transfer, screening, and combinations thereof. Each of the thermochromatic materials responds chromatically within a different operating temperature range. In an alternative embodiment, the thermochromatic external liquid level gauge further includes a substrate having a series of indicia printed thereon, in which the substrate is directly applied to the outside surface of the outside wall of the container.

DIRECTLY APPLIED THERMOCHROMATIC EXTERNAL LIQUID LEVEL GAUGE AND METHOD

FIELD OF THE INVENTION:

[0001] This invention relates to a liquid level gauge, and particularly relates to a thermochromatic external liquid level gauge which is directly applied to the outside surface of the outside wall of a container, for use in the determination of the level of the interface between a mass of flowable material and the void volume above the mass of flowable material within a container, and to the method by which it is directly applied. Thus, the present invention further relates to the direct application of the thermochromatic external liquid level gauge to the outside surface of the outside wall of the container by such methods as painting, silk screening, stencilling, molding, crayon transfer, pencil transfer or screening.

BACKGROUND OF THE INVENTION:

[0002] Liquid level measuring devices have been known for many years. Their purpose is to locate the level of a flowable material, or to indicate the amount of flowable material remaining in a container.

[0003] On many occasions, monitoring the amount of flowable material in a container is required. However, direct observation of the flowable material level is not always possible or practical. Measurement of the material in such containers as pressurized cylinders, sealed containers, cryogenic flasks, and opaque vessels is often difficult. Such measurements are even more troublesome when the material within the container is corrosive or potentially toxic or flammable.

[0004] Sight glasses and weight scales are some examples of liquid level measuring devices which are commonly employed. Both of these devices suffer from a number of disadvantages. Sight glasses are expensive, and they can crack and break easily. On such occasions where the container is placed outdoors, ultraviolet light can

cause the glass to haze. Weight scales also are expensive, and in many instances, measurements provided by weight scales are inexact.

[0005] A simple, economical external liquid level gauge which permits a direct reading of the level of a flowable material has been provided by the present inventor in CA patent No. 1,177,281 issued on November 6, 1984. The liquid level measuring device taught therein employs one thermochromatic material. The device is a significant improvement from sight glasses and weight scales. It can be repeatedly removed and reattached to the outside wall of a container. Furthermore, it requires no alteration of the container or the use of tools or other auxiliary equipment.

[0006] The theory is that the rate of heat transfer is different between a mass of flowable material and the void volume above it such that for any container with a modest heat conducting capability, the container wall experiences a temperature gradient which is most pronounced at the interface of the contents with the void volume above the contents, and of course below that interface. That is to say, the rate of heat transfer through the wall of a container will be greater where there is a mass of flowable material located in the container than where there is a void volume above the flowable material. In other words, the rate of heat transfer through the container wall changes most abruptly at the level of the interface, and below. Thus, with the use of a thermochromatic material, a vivid color change occurring at the interface, and below, will permit an observer to obtain a direct reading of the level of the flowable material within a container by discerning where the interface is located.

[0007] Although the above external liquid level gauge provided by the present inventor proved to the useful, the present inventor has also filed a co-pending Canadian application, Serial No. 2,338,407 on February 26, 2001 which teaches an external liquid level gauge comprising at least two thermochromatic materials. The external liquid level gauge as taught therein allows the user to be able to discern much more readily and accurately the level of the interface between the mass of flowable material within the

container and the void volume above it. Each thermochromatic material is disposed entirely along the length of the gauge which is adapted to be affixed vertically to the outside wall of the container. Since each thermochromatic material responds chromatically within a different temperature range, a slight change in temperature in the region of the external liquid level gauge can be readily discerned visually by a vivid color change.

[0008] Although the external liquid level gauges provided by the present inventor in the prior art may be repeatedly removed and reattached to the outside surface of the outside wall of a container since the base material of each of these external liquid level gauges has adhesive or magnetic properties, a disadvantage of these external liquid level gauges is that the thermochromatic materials are not in direct contact with the outside surface of the outside wall of the container, and thus the chromatic response of the thermochromatic material is delayed. Furthermore, due to the presence of the additional base layer, these prior art external liquid level gauges may not provide a pronounced color change at the level of the interface, and thus the accuracy of these devices is affected.

[0009] Quite surprisingly, the present inventor herein has discovered that a thermochromatic external liquid level gauge may be directly applied to the outside surface of the outside wall of a container, for use in the determination of the level of the interface between a mass of flowable material and the void volume above the mass of flowable material within the container. The thermochromatic external liquid level gauge of the present invention may be applied to the outside surface of the outside wall of the container by such methods as painting, silk screening, stencilling, molding, crayon transfer, pencil transfer, screening and combinations thereof. Since the thermochromatic external liquid level gauge provided herein does not employ a base material, the chromatic response of the thermochromatic materials is expedited and the color change at the level of the interface is also significantly more pronounced.

[0010] As employed herein, the term "flowable material" is intended to mean any fluidic matter in which the shape of a given mass depends on the container but the volume is independent thereof. "Flowable material" is also intended to mean any fluid matter which seeks a level and offers no permanent resistance to change of shape. The term may include any mass of granular material which has fluidic properties.

[0011] The expression "thermochromatic materials" as used herein is intended to mean materials that have or exhibit different colors or shades of color at different temperatures. The expression "responding chromatically" as used herein is intended to mean having or exhibiting different colors or shades of color at different temperatures.

DESCRIPTION OF THE PRIOR ART:

[0012] Several prior art thermochromatic external liquid level gauges are now described. They include GILMOUR United States patent No. 3,696,675 issued October 10, 1972, which teaches an external liquid level gauge adapted to be permanently affixed to the outside wall of a container for determining the liquid-gas interface within the container. The external liquid level gauge described therein consists of a uniform thermochromatic liquid crystalline material which coats the entire base layer of the gauge such that it is at right angles to the liquid-gas interface. The uniform thermochromatic material covers the entire temperature range to which the container is subjected within an overall range of -20°C to 250°C. Depending upon the thermochromatic material selected, color changes over a gradient from violet to red can occur in a range as small as 2°C to one as broad as 150°C. Since the temperature differential across the liquid-gas interface is generally small, on the order of less than 2°C, the change in color is slight across the interface. This is particularly the case when the container is placed outdoors and a large temperature range needs to be covered. As a result, it is difficult to visually locate the liquid-gas interface.

[0013] In United States patent No. 5,323,652 issued June 28, 1994 to PARKER, the inventor teaches a thermochromatic level indicator for determining the level of a material inside a container. The thermochromatic level indicator includes at least two thermochromic materials of different opacities and transition temperature. Prior to the attachment of the thermochromatic level indicator to the outside surface of the outside wall of the container, the thermochromic materials are applied to a transparent film by silk screening, other printing and coating methods, or methods which employ the use of microencapsulated thermochromic materials. The thermochromatic level indicator may be permanently adhered to the container wall or it may be adhered to a magnetic strip which can be temporarily affixed to the container wall.

[0014] In another United States patent No. 5,707,590, issued January 13, 1998, the inventor THOMAS *et al.* has provided a detergent container with a thermochromatic level indicator. In one embodiment of the invention, the thermochromatic substance is added to the container's plastic material during the molding process. In another embodiment of the invention, the level indicator or strip comprises a base material, such as Mylar, which is coated or imbedded with a thermochromatic substance by such methods as painting, stripping, or screen printing.

[0015] In Canadian patent No. 1,177,281 issued on November 6, 1984, the present inventor herein has provided a liquid level gauge for externally determining the level of a mass of flowable material such as liquid or granular material contained in a closed or sealed container. Only one thermochromic substance is employed and it is coated onto a base layer which is magnetically mounted to the outside surface of the outside wall of the container. The external liquid level gauge can be repeatedly removed and replaced or relocated when necessary.

[0016] In a Canadian co-pending application, Serial No. 2,338,407 filed February 26, 2001, for "External Liquid Level Gauge," an external liquid level gauge which is adapted to be affixed vertically to the outside wall of a container is described. That

external liquid level gauge is in the form of an elongated strip and it comprises a layer of base material and a layer of thermochromatic materials. Furthermore, the thermochromatic layer comprises a light absorbing background and at least two regions of thermochromatic materials which are arranged upon the light absorbing background. The regions of at least two thermochromatic materials are disposed in arrays thereof and are arranged entirely along the length of the external liquid level gauge. Moreover, each of the thermochromatic materials is arranged in an individual area and each thermochromatic material responds chromatically within a different operating temperature range.

SUMMARY OF THE INVENTION:

[0017] In accordance with one aspect of the present invention, there is provided a thermochromatic external liquid level gauge which is directly applied to the outside surface of the outside wall of a container, for use in the determination of the level of the interface between a mass of flowable material and the void volume above the mass of flowable material within a container. The thermochromatic external liquid level gauge of the present invention vertically extends along substantially the entire height of the container.

[0018] The flowable material within the container has fluidic properties, and it has a faster rate of heat transfer than the void volume above it within the container.

[0019] The thermochromatic external liquid level gauge of the present invention is in intimate heat transfer relationship with the outside wall of the container. Additionally, at least that portion of the outside surface which underlies the thermochromatic external liquid level gauge has light absorbing properties.

[0020] The thermochromatic external liquid level gauge includes at least two thermochromatic materials, and the at least two thermochromatic materials are directly

applied to the outside surface of the outside wall of the container. Furthermore, the at least two thermochromatic materials are arranged in at least two regions.

[0021] Still further, each of the at least two regions of thermochromatic materials is arranged in an individual area upon the outside surface of the outside wall of the container. Each of the thermochromatic materials responds chromatically within a different operating temperature range.

[0022] The regions of the at least two thermochromatic materials are disposed in arrays thereof arranged entirely along the length of the thermochromatic external liquid level gauge in the vicinity between the bottom end of the gauge and the top end of the gauge.

[0023] Each of the at least two thermochromatic materials is directly applied to the outside surface of the outside wall of the container by an application method chosen from the group consisting of painting, silk screening, stencilling, molding, crayon transfer, pencil transfer, screening, and combinations thereof.

[0024] Each of the at least two thermochromatic materials is carried to the outside surface of the outside wall of the container during the application method by a transfer medium.

[0025] Typically, at least that portion of the outside surface of the outside wall of the container which underlies the thermochromatic external liquid level gauge has been treated by an application method chosen from the group consisting of anodizing, anti-oxidizing, rust-proofing, and combinations thereof, so as to provide at least that portion of the outside surface of the outside wall with a light absorbing property, prior to the direct application of the thermochromatic external liquid level gauge to the outside surface of the outside wall of the container.

[0026] The flowable material within the container may be chosen from the group consisting of water, alcohol, oil, coffee, tea, juice, milk, liquefied gas, corrosive liquid and granular material.

[0027] In keeping with the present invention, the thermochromatic external liquid level gauge is directly applied to the outside surface of the outside wall of the container chosen from the group of containers consisting of pressurized cylinders, open containers, sealed containers, cryogenic flasks, and opaque vessels, so as to determine the level of the interface between the mass of flowable material and the void volume above the mass of flowable material within the container to which the thermochromatic external liquid level gauge is directly applied.

[0028] Typically, but not necessary, the thermochromatic external liquid level further includes an ultraviolet filter layer, which overlies the at least two thermochromatic materials.

[0029] The thermochromatic materials are chosen from the group of cholesteric liquid crystal compounds and mercurous oxide. Furthermore, the at least two thermochromatic materials in the array have overlapping operating temperature ranges. Still further, each of the thermochromatic materials in the array displays a color gradient within its operating temperature range.

[0030] Each of the thermochromatic materials is arranged in the individual area chosen from the group of geometric configurations consisting of dots, circles, stars, squares, triangles, arrows, semi-circles, pentagons, hexagons, digits and letters.

[0031] The regions of thermochromatic materials are arranged on the outside surface of the outside wall of the container chosen from the group of arrays consisting of one of the regions of thermochromatic materials vertically positioned down the center of the gauge and at least one other region diagonally positioned on each side of the vertically positioned region of the gauge, all of the regions of thermochromatic materials vertically positioned upon the gauge, all of the regions of thermochromatic materials diagonally positioned upon the gauge, and all of the regions of thermochromatic materials horizontally positioned upon the gauge.

[0032] In a particular embodiment of the present invention, the at least two adjacent regions of thermochromatic materials are arranged to form a set. Moreover, the set is disposed vertically along the entire length of the thermochromatic external liquid level gauge in a repeated manner.

[0033] In keeping with another embodiment of the present invention, a thermochromatic external liquid level gauge which includes a substrate and a series of indicia printed thereon is also provided by the present inventor. The substrate is directly applied to the outside surface of the outside wall of the container. The indicia are vertically positioned along the entire length of the substrate and at predetermined spaced-apart locations.

[0034] Similar to the thermochromatic external liquid level gauge described above, the thermochromatic external liquid level gauge herein includes at least two thermochromatic materials. Each of the at least two regions of thermochromatic materials is arranged in an individual area upon the substrate, and each of the thermochromatic materials responds chromatically within a different operating temperature range. Furthermore, the regions of the at least two thermochromatic materials are disposed in arrays thereof arranged entirely along the length of the thermochromatic external liquid level gauge in the vicinity between the bottom end of the substrate and the top end of the substrate. Moreover, each of the at least two thermochromatic materials is applied to the substrate by an application method chosen from the group consisting of painting, silk screening, stencilling, molding, crayon transfer, pencil transfer, screening, and combinations thereof.

[0035] The series of indicia on the substrate underlie the at least two thermochromatic materials, and typically, the substrate has light absorbing properties. Until such time when at least a portion of one of the at least two thermochromatic materials on the substrate, when placed on the outside surface of the outside wall of the container, becomes activated, the indicia on the substrate remain invisible. However,

when activated, at least the portion of one of the at least two thermochromatic materials on the substrate, which is placed on the outside surface of the outside wall of the container becomes translucent, so as to reveal at least one of the indicia printed on the substrate.

[0036] Typically, but not necessarily, the thermochromatic external liquid level gauge further includes a protective clear lamina where the protective clear lamina overlies the at least two thermochromatic materials. Still further, the protective clear lamina may be an ultraviolet filter.

[0037] Another object of the present invention is to provide a method of determining the level of the interface between a mass of flowable material and the void volume above it within a container using a thermochromatic external liquid level gauge, which is applied to the outside surface of the outside wall of the container. The flowable material within the container has fluidic properties, and the flowable material has a faster rate of heat transfer than the void volume above it within the container. The thermochromatic external liquid level gauge would be, of course, as described above. It is important to note that the thermochromatic external liquid level gauge includes at least two thermochromatic materials, and it has an outer surface remote from the outside surface of the container. The method comprises the steps of:

(i) inducing heat transfer between the thermochromatic external liquid level gauge and the mass of flowable material within the container; and

(ii) discerning visually a color change in the at least one region of the array of the thermochromatic external liquid level gauge.

[0034] The region noted above which responds chromatically to a temperature change is contiguous to the mass of flowable material within the container. Specifically, step (i) may be achieved by any of the steps chosen from the group of steps consisting of:

(a) spraying a liquid onto the outer surface of the thermochromatic external liquid level gauge;

(b) wetting the outer surface of the thermochromatic external liquid level gauge, with a moistened cloth or sponge;

(c) pouring a liquid down the outer surface of the thermochromatic external liquid level gauge; and

(d) trickling a liquid down the outer surface of the thermochromatic external liquid level gauge.

[0035] Typically, at least that portion of the outside surface of the outside wall of the container which underlies the thermochromatic external liquid level gauge has been treated by an application method chosen from the group consisting of anodizing, anti-oxidizing, rust-proofing, and combinations thereof, so as to provide at least that portion of the outside surface of the outside wall with a light absorbing property, prior to the direct application of the thermochromatic external liquid level gauge to the outside surface of the outside wall of the container.

[0036] Each of the at least two thermochromatic materials is directly applied to the outside wall of the container by an application method chosen from the group consisting of painting, silk screening, stencilling, molding, crayon transfer, pencil transfer, screening, and combinations thereof.

[0037] In one embodiment of the present invention, the liquid as employed above in any of steps (a) through (d) is a heat source. Since the temperature of the liquid is above the temperature of the flowable material within the container, heat transfer is induced from the liquid to the flowable material.

[0038] In another embodiment of the present invention, the liquid as employed above in any of steps (a) through (d) is a heat sink. Here, the temperature of the liquid is below the temperature of the flowable material within the container. Thus, heat transfer is induced to the liquid from the flowable material within the container.

[0039] In yet another embodiment of the present invention, at least two adjacent regions of the thermochromatic external liquid level gauge are arranged to form a set, which comprises the at least two thermochromatic materials. The set is disposed vertically along the entire length of the thermochromatic external liquid level gauge in a repeated manner.

[0040] Particularly when a plurality of sets are disposed in a repeated manner vertically along the length of the thermochromatic external liquid level gauge, the method of determining the level of the interface between a mass of flowable material and the void volume above it within a container may also further comprise the step of:

(iii) estimating the level of the interface between the mass of flowable material and the void volume above the mass of flowable material within the container using the thermochromatic external liquid level gauge where the estimated area falls between a level having a profound color change and a level having a faint color change.

[0041] These and other objects of the present invention are discussed in greater detail hereafter, in association with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0042] The novel features which are believed to be characteristic of the present invention, as to its structure, organization, use and method of operation, together with further objectives and advantages thereof, will be better understood from the following drawing in which a presently preferred embodiment of the invention will now be illustrated by way of example. It is expressly understood, however, that the drawing is for the purpose of illustration and description only and is not intended as a definition of the limits of the invention. Embodiments of this invention will now be described by way of example in association with the accompanying drawing in which:

[0043] **Figure 1** is a front view of a thermochromatic external liquid level gauge in keeping with the present invention, when affixed to the outside surface of the outside wall of a container;

[0044] **Figure 2** is a transverse sectional view taken on line II–II of the thermochromatic external liquid level gauge in keeping with the present invention as shown in Figure 1, greatly enlarged;

[0045] **Figure 3** is a front view of the thermochromatic array of a first embodiment of the thermochromatic external liquid level gauge in keeping with the present invention;

[0046] **Figure 4** is a front view of the thermochromatic array of a second embodiment of the thermochromatic external liquid level gauge in keeping with the present invention;

[0047] **Figure 5** is a front view of the thermochromatic array of a third embodiment of the thermochromatic external liquid level gauge in keeping with the present invention;

[0048] **Figure 6** is a front view of the thermochromatic array of a fourth embodiment of the thermochromatic external liquid level gauge in keeping with the present invention;

[0049] **Figure 7** is a front view of the thermochromatic array of a fifth embodiment of the thermochromatic external liquid level gauge in keeping with the present invention, when directly applied to the outside surface of the outside wall of the container; and

[0050] **Figure 8** is a front view of the thermochromatic array of a sixth embodiment of the thermochromatic external liquid level gauge in keeping with the present invention, when directly applied to the outside surface of the outside wall of the container

[0051] **Figure 9** is a front view of the thermochromatic array of the thermochromatic external liquid level gauge in keeping with an alternative embodiment of the present invention, when a substrate is directly applied to the outside surface of the outside wall of the container.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

[0052] The novel features which are believed to be characteristic of the present invention, as to its structure, organization, use and method of operation, together with further objectives and advantages thereof, will be better understood from the following discussion.

[0053] As noted above, a feature of the present invention is essentially to provide a thermochromatic external liquid level gauge, which is directly applied to the outside surface of the outside wall of a container, for use in the determination of the level of the interface between a mass of flowable material and the void volume above the mass of flowable material within a container. The thermochromatic external liquid level gauge of the present invention is directly applied to the outside surface of the outside wall of the container by such methods as painting, silk screening, stencilling, molding, crayon transfer, pencil transfer, screening and combinations thereof.

[0054] Turning first to Figure 1, a front view of a thermochromatic external liquid level gauge 10 is shown. The thermochromatic external liquid level gauge 10 is applied to the outside surface 13 of the outside wall 12 of a container 14, vertically extending along substantially the entire height of the container 14. The thermochromatic external liquid level gauge 10 is in intimate heat transfer relationship with the outside wall 12 of the container 14.

[0055] The container 14 is shown as being partially filled with a flowable material 16. The flowable material 16 is in intimate contact with the interior surface 11 of the wall 12. A void volume 18 is above the interface 20 of the flowable material 16.

[0056] The flowable material 16 within container 14 has fluidic properties, and it has a faster rate of heat transfer than the void volume 18 above it. A typical flowable material 16 within the container 14 may be water. Other flowable materials 16 that may be found within the container 14 may be alcohol, oil, coffee, tea, juice, milk, corrosive liquids, liquefied gases – particularly such as carbon dioxide – or even granular materials.

[0057] It is noted that the container 14 to which the thermochromatic external liquid level gauge 10 is directly applied to the outside surface 13 of the outside wall 12 may be a pressurized cylinder, an open container, a sealed container, a cryogenic flask, or an opaque container.

[0058] It is noted that at least that portion of the outside surface 13 which underlies the thermochromatic external liquid level gauge 10 has light absorbing properties.

[0059] The thermochromatic external liquid level gauge 10 includes at least two thermochromatic materials 32 with reference to Figure 2. The at least two thermochromatic materials 32 are directly applied to the outside surface 13 of the outside wall 12 of the container 14, and are arranged in at least two regions 36, as shown hereinafter in Figures 3 through 8. The regions 36 of the at least two thermochromatic materials 32 are arranged entirely along the length of the thermochromatic external liquid level gauge 10, in the vicinity between the bottom end of the gauge and the top end of the gauge. Furthermore, each of the at least two regions 36 of thermochromatic materials 32 is arranged in an individual area upon the outside surface 13 of the outside wall 12 of the container 14. The thermochromatic external liquid level gauge 10 may also include an ultraviolet filter layer 40 which overlies the at least two thermochromatic materials 32.

[0060] Thermochromatic materials 32 made by the Thermochromatic Liquid Crystal division of Thermographic Measurements Limited may be effectively employed. The thermochromatic materials 32 used are preferably reversible or thermotropic.

Cholesteric liquid crystal compounds are most suitable. These compounds behave mechanically like liquids but exhibit the optical properties of crystals. They exhibit vivid color changes with only slight changes in temperature.

[0061] The thermochromatic materials 32 cover the entire temperature range to which the container 14 is subjected, within an overall range of -20°C to 250°C. Some examples of thermochromatic materials 32 which may be employed are cholesteryl oleate, cholesteryl oleyl carbonate, and mercurous oxide. Each thermochromatic material 32 responds chromatically within a different operating temperature range. Cholesteryl oleate has an operating temperature range between 32.2°C to 63.9°C while cholesteryl oleyl carbonate has an operating temperature range between 29.2°C to 39.2°C. Furthermore, each of the thermochromatic materials 32 displays a color gradient within its operating temperature range.

[0062] Typically, prior to the direct application of the thermochromatic external liquid level gauge 10 to the outside surface 13 of the outside wall 12 of the container 14, at least that portion of the outside surface 13 of the outside wall 12 of the container 14 which underlies the thermochromatic external liquid level gauge 10 has been treated by an application method chosen from the group consisting of anodizing, anti-oxidizing, rust-proofing, and combinations thereof, so as to provide at least that portion of the outside surface 13 of the outside wall 12 with a light absorbing property. The light absorbing portion of the outside surface 13 of the outside wall 12 of the container 14 absorbs any light transmitted through the thermochromatic material 32, and allows selectively reflected light to be observed without light interference. Since each thermochromatic material 32 responds chromatically within a different temperature range, the selectively reflected light is determined by orientation change of the thermochromatic material 32 in response to temperature.

[0063] The additional ultraviolet filter layer 40 prevents the deterioration of the thermochromatic external liquid level gauge 10. It has been reported that long and

continuous exposure to ultraviolet radiation causes the thermochromatic materials 32 to deteriorate and lose their temperature responsive chromatic characteristic which is necessary for the purpose of utilization as a thermochromatic external liquid level gauge as described herein. This is particularly the case when the container 14 is placed outdoors where it is subjected to sunlight for a long period of time.

[0064] Depending upon the thermochromatic material 32 selected, color changes over a gradient can occur in a range as small as 2°C to one as broad as 150°C. For a thermochromatic material 32 with a large operating temperature range, the color difference across the interface 20 is small.

[0065] As noted above, the rate of heat transfer is different between the mass of flowable material 16 and the void volume 18 above it such that for any container 14 with a modest heat conducting capability, the container wall 12 experiences a temperature gradient which is most pronounced at and below the interface 20 between a mass of flowable material 16 and the void volume 18 above it within a container 14. In other words, the temperature of the container wall 12 changes most abruptly at and below the level of the interface 20.

[0066] In an outdoor environment, the container 14 may be subjected to varying temperature, from below 0°C to over 37.8°C. In that particular case, five to seven different thermochromatic materials 32 in the thermochromatic external liquid level gauge 10 are employed where each thermochromatic material 32 has an operating temperature range of about 8°C. In more stable environments such as a residence or an office – or even in stores, warehouses, and factories – where temperatures often fall between 16°C to 29°C, two to five thermochromatic materials 32 are most effective. In such environments where temperatures range from about 16°C to 27°C, two thermochromatic materials 32 with an operating temperature range of about 8°C or five thermochromatic materials 32 with each having an operative temperature range of about 3°C may also be effectively employed.

[0067] Moreover, the operating temperature ranges of at least two thermochromatic materials 32 in the thermochromatic external liquid level gauge 10 may be overlapped. A temperature response may be invoked from two thermochromatic materials 32 in the thermochromatic external liquid level gauge 10, thus making the level of the interface 20 between a mass of flowable material 16 and the void volume 18 above it within a container 14 easier to observe. For instance, the upper operating temperature of a first thermochromatic material may be 10°C, the temperature differential across the interface 20 may be 2°C, and the temperatures of the mass of flowable material 16 and the void volume 18 above it within the container 14 may be 9°C and 11°C respectively. On such occasion, a color change occurs for the end of the first thermochromatic material which responds to the lower operating temperature range while a color change also occurs for the adjacent end of a second thermochromatic material which responds within the higher operating temperature range. In order to determine the level of the interface 20, readings of both thermochromatic materials are necessary. If two thermochromatic materials 32 having overlapping operating temperature ranges are employed, the level may be readily discerned visually.

[0068] Turning now to Figures 3 through 6, the regions 36 of at least two thermochromatic materials 32 are disposd in arrays thereof, designated by reference numerals 50, 52, 54 and 56.

[0069] Each of the thermochromatic materials 32 is arranged upon at least that light absorbing portion of the outside surface 13 of the outside wall 12 of the container 14 in an individual area which may have any of the following geometric configurations such as dots, circles, stars, squares, triangles, arrows, semi-circles, pentagons, hexagons, digits, and letters.

[0070] As can be seen in Figure 3, the thermochromatic array 50 comprises five regions 36a, 36b, 36c, 36d, and 36e, each region having a respective thermochromatic material. The region 36a is positioned vertically down the

center of array 50. Regions 36b and 36c are arranged on one side of the vertically positioned region 36a while regions 36d and 36e are arranged on the other side of region 36a. The four regions 36b, 36c, 36d and 36e are arranged in a diagonal manner, repeatedly over the length of array 50. The thermochromatic material of region 36a has the lowest operating temperature range of the group of thermochromatic materials 32 found in array 50 while the thermochromatic materials of regions 36b and 36c have the next two highest operating temperature ranges, and the thermochromatic materials of regions 36d and 32e have the two most highest operating temperature ranges. It is preferred that the thermochromatic material with the lowest operating temperature range (that of region 36a) exhibits a "cool" color such as blue and the thermochromatic material with the highest operating temperature range (that of region 36e) exhibits a "hot" color such as red to aid in the locating of the interface 20 between the mass of flowable material 16 and the void volume 18.

[0071] For outdoor use, five thermochromatic materials, each responding within a different temperature range, preferably of about 8°C, are chosen such that the full range of all the operating temperature ranges covers the range of temperatures to which array 50 may be most likely exposed.

[0072] The upper temperature of the thermochromatic material of region 36a may slightly overlap the lower limit of the operating temperature range of the thermochromatic material of region 36b, and so on with each additional thermochromatic material 32 within array 50 sequentially to the thermochromatic material which has the highest operating temperature range. For instance, by using this overlap system, a color change occurs in two adjacent thermochromatic materials when the temperature at the interface 20 bridges the two thermochromatic materials. Thus, the interface 20 is readily discerned visually.

[0073] When the thermochromatic external liquid level gauge 10 is placed indoors where the atmosphere is often controlled and potential temperature variations are generally much smaller than outdoors, the thermochromatic materials 32 in the array 50

may be chosen such that they have operating temperature ranges within the possible outer limits for thermochromatic materials 32 but also such that they have operating temperature ranges as small as 3°C.

[0074] Referring now to Figure 4, a different embodiment of the present invention is shown. Thermochromatic array 52 comprises five regions 36a, 36b, 36c, 36d and 36e arranged vertically upon at least that light absorbing portion of the outside surface 11 of the outside wall 12 of the container 14, each region having a respective thermochromatic material.

[0075] In another embodiment of the present invention shown in Figure 5, the thermochromatic array 54 comprises five regions 36a, 36b, 36c, 36d, and 36e disposed along at least that light absorbing portion of the outside surface 13 of the outside wall 12 of the container 14, each region having a respective thermochromatic material. Here, the regions 36a, 36b, 36c, 36d and 36e are arranged in a diagonal manner, repeatedly over the entire length of array 54. The angle along the longitudinal axis of array 54 that the diagonal regions 36a, 36b, 36c, 36d and 36e are disposed may vary, but is preferably 45°C. As can be seen particularly in Figure 5 and the following Figure 6, at least two adjacent regions 36 are combined to form a set 39 and a plurality of such sets 39 are disposed in a repeated manner vertically along the length of the thermochromatic external liquid level gauge 10.

[0076] In yet another embodiment of the present invention shown in Figure 6, the regions 36a, 36b, 36c, 36d and 36e comprising the thermochromatic materials of array 56 are arranged in a horizontal manner. As noted above, the five regions 36a, 36b, 36c, 36d and 36e combine to form a set 39 and a plurality of such a set 39 are disposed along the length of array 56.

[0077] In keeping with the present invention, the at least two thermochromatic materials 32 are directly applied to at least that light absorbing portion of the outside surface 13 of the outside wall 12 of the container 14 by such methods as painting, silk

screening, stencilling, molding, crayon transfer, pencil transfer, screening and combinations thereof. In each of these application methods, each of the at least two thermochromatic materials 32 is carried to the outside surface 13 of the outside wall 12 of the container 14 by a transfer medium. The transfer medium chosen for the transferring of each of the at least two thermochromatic materials 32 to the outside surface 13 of the outside wall 12 of the container is such that it does not interfere with the thermochromatic response of the transferred thermochromatic materials 32. Furthermore, an important property of the transfer medium chosen herein is high volatility. Thus, the transfer medium may be evaporated quickly once each of the at least two thermochromatic materials 32 is delivered to the outside surface 13 of the outside wall 12 of the container.

[0078] Since each of the thermochromatic materials 32 is directly applied to the outside surface 13 of the outside wall 12 of the container 14, the accuracy of the thermochromatic external liquid level gauge 10 is significantly increased in comparison to those external liquid level gauges which require a base layer to magnetically adhere or permanently adhere to the outside surface 13 of the outside wall 12 of the container 14. Here, without the presence of the base layer, the thermal mass of the thermochromatic external liquid level gauge 10 is reduced. Thus, the chromatic response of the thermochromatic materials is expedited, and the color change at the level of the interface 20 between the mass of flowable material 16 and the void volume 18 above it within the container 14 is also significantly more pronounced.

[0079] However, in certain circumstances, due to the particular nature of the outside surface 13 of the outside wall 12 of the container 14, direct application of the thermochromatic materials 32 onto the outside surface 13 of the outside wall of the container 14 may not be feasible. Thus, the present inventor herein also provides a thermochromatic external liquid level gauge 70 which further includes a substrate 41 in which the substrate 41 is directly applied to the outside surface 13 of the outside wall 12

of the container 14. The substrate 41 has a series of indicia 37 printed thereon to aid the user to accurately determine the level of the interface 20. With reference to Figure 9, the indicia 37 are vertically positioned along the entire length of the substrate 41 and at predetermined spaced-apart locations. Similar to the thermochromatic external liquid level gauge 10 described above, the thermochromatic external liquid level gauge 70 includes at least two thermochromatic materials 32. Each of the at least two regions 36 of thermochromatic materials 32 is arranged in an individual area upon the substrate 41, and each of the thermochromatic materials 32 responds chromatically within a different operating temperature range. The regions 36 are disposed in arrays thereof arranged entirely along the length of the thermochromatic external liquid level gauge 70 in the vicinity between the bottom end of the substrate 41 and the top end of the substrate 41. Each of the at least two thermochromatic materials 32 is applied to the substrate 41 by an application method chosen from the group consisting of painting, silk screening, stencilling, molding, crayon transfer, pencil transfer, screening, and combinations thereof. As shown in Figure 9, the thermochromatic array 57 comprises two thermochromatic materials which are disposed along the entire length of the substrate 41 in respective regions 36a and 36b.

[0080] It is important to note that the series of indicia 37 on the substrate 41 underlies the at least two thermochromatic materials 32, and are shown as ghost lines in Figure 9. Furthermore, the substrate 41 may have light absorbing properties.

[0081] Until such time when at least a portion of one of the at least two thermochromatic materials 32 on the substrate 41, when placed on the outside surface 13 of the outside wall 12 of the container 14, becomes activated, the indicia 37 on the substrate 41 remain invisible. However, when at least the portion of one of the at least two thermochromatic materials 32 on the substrate 41, which is placed on the outside surface 13 of the outside wall 12 of the container 14, is activated, that at least portion of

one of the at least two thermochromatic materials 32 becomes translucent, so as to reveal at least one of the indicia 37 printed on the substrate 41.

[0082] Typically, but not necessarily, the thermochromatic external liquid level gauge 70 further includes a protective clear lamina 35, and the protective clear lamina 35 overlies the at least two thermochromatic materials 32. Moreover, the protective clear lamina may also serves as an ultraviolet filter.

[0083] In keeping with the provisions of the present invention, the inventor herein provides a method of determining the level of the interface 20 between a mass of flowable material 16 and the void volume 18 above it within a container 14 using a thermochromatic external liquid level gauge 10 described above. It is important to note that the thermochromatic external liquid level gauge 10 includes at least two thermochromatic materials 32, and has an outer surface remote from the outside surface 13 of the container 14.

[0084] In a steady state ambient environment, it is possible that little or no temperature differential exists at the interface 20 between the mass of flowable material 16 and the void volume 18 within the container 14. The addition or withdrawal of thermal energy to or from the container 14 and the mass of flowable material 16 is required to cause a temperature differential across the interface 20 to occur, and thus inducing a color change response from the thermochromatic materials 32 in turn. As noted above, the void volume 18 above the mass of flowable material 16 generally absorbs or releases far less thermal energy than the mass of flowable material 16, causing a measurable temperature differential at the interface 20.

[0085] Thus, the method of determining the interface 20 between the mass of flowable material 16 and the void volume 18 first comprises the step of inducing heat transfer between the thermochromatic external liquid level gauge 10 and the mass of flowable material 16 within the container 14. The occurrence of a temperature differential across the interface 20 will then induce a color change in at least one region

36 of the array of the thermochromatic external liquid level gauge 10, allowing the interface 20 to be readily discerned visually. It is important to note that the region 36 which responds chromatically to a temperature change is contiguous to the mass of flowable material 16 within the container 14.

[0086] Specifically, the first step which involves the induction of heat transfer may be carried out by any of the steps chosen from the group of steps consisting of:

(a) spraying a liquid onto the outer surface of the thermochromatic external liquid level gauge 10;

(b) wetting the outer surface of the thermochromatic external liquid level gauge 10, with a moistened cloth or sponge;

(c) pouring a liquid down the outer surface of the thermochromatic external liquid level gauge 10; and

(d) trickling a liquid down the outer surface of the thermochromatic external liquid level gauge 10.

[0087] When the liquid as described above is a heat source, the temperature of the liquid is above the temperature of the flowable material 16 within the container 14, thus heat transfer is induced from the liquid to the flowable material 16. Indeed, steam from a steam gun may be employed if a large temperature gradient between the heat source and the flowable material 16 is desired. On the other hand, when the liquid is a heat sink, the temperature of the liquid is below the temperature of the flowable material 16 within the container 14, thus heat transfer is induced from the flowable material 16 to the liquid.

[0088] For the purpose of illustration, a large sealed container 14 with a thermochromatic external liquid level gauge 10 directly applied to the outside surface 13 of the outside wall 12 is placed in a warehouse or factory where the temperature generally falls between 5°C and 35°C. The five thermochromatic materials of the thermochromatic external liquid level gauge 10 are arranged in

respective regions 36a, 36b, 36c, 36d and 36e as shown in array 58 with reference to Figure 7. The operating temperature ranges of regions 36a, 36b, 36c, 36d and 36e are as follows:

REGION	Operating Temperature Range
36a	0°C - 9°C
36b	7°C - 16°C
36c	14°C - 23°C
36d	21°C - 30°C
36	28°C - 37°C

[0084] The flowable material 16 within container 14 is at a temperature of 15°C. In order to determine the level of the interface 20 between the flowable material 16 and the void volume 18 above it, a liquid which is at a temperature of 50°C is sprayed onto the outer surface of the thermochromatic external liquid level gauge 10. Here, a temperature response is invoked from two regions 36b and 36c. A color change occurs in region 36b which responds to the upper limit of its operating temperature range while a color change also occurs for the adjacent region 36c which responds to the lower limit of its operating temperature range. Due to the overlapping operating temperature ranges of the regions 36, readings of both regions 36b and 36c are necessary to readily discern visually the level of the interface 20.

[0085] In yet another example, the thermochromatic external liquid level gauge 10 is directly applied to the outside surface of the outside wall 12 of a large sealed container 14 which is exposed to the same environment as described above. The thermochromatic external liquid level gauge 10 also comprises five regions 36a, 36b, 36c, 36d and 36e which respond to the same operating temperature ranges as illustrated

in the above Table. The only exception is that the regions 36a, 36b, 36c, 36d and 36e are arranged in a horizontal manner, as particularly seen in Figure 7. Furthermore, the five regions 36a, 36b, 36c, 36d and 36e are combined to form a set 39 and a plurality of such a set 39 are disposed along the length of array 59. As shown in Figure 8, eleven such sets 39a, 39b, 39c, 39d, 39e, 39f, 39g, 39h, 39i, 39j, and 39k are found in array 59 and the mass of flowable material 16 is contiguous to sets 39a, 39b, 39c, 39d and 39e. When the liquid (50°C) is sprayed onto the outer surface of the thermochromatic external liquid level gauge 10, a temperature response is invoked from the two regions 36b and 36c in each of set 39a, 39b, 39c, 39d, 39e and 39f. Since the void volume 18 above the mass of flowable material 16 generally absorbs or releases far less thermal energy than the mass of flowable material 16, a color change in regions 36b and 36c of sets 39a, 39b, 39c, 39d and 39e is more pronounced than in regions 36b and 36c of set 39f. In order to determine the level of the interface 20 between the mass of flowable material 16 and the void volume 18 above it within container 14, the method further comprises the step of estimating the level of the interface 20 between the mass of flowable material 16 and the void volume 18 above it. The estimated area, in this case, falls between set 39e where the color change is profound and set 39f where the color change is faint.

[0086] Other modifications and alterations may be used in the design and manufacture of the apparatus of the present invention without departing from the spirit and scope of the accompanying claims.

[0087] Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not to the exclusion of any other integer or step or group of integers or steps.

[0088] Moreover, the word "substantially" when used with an adjective or adverb is intended to enhance the scope of the particular characteristic; e.g., substantially the entire height is intended to mean most, if not all, of the height.

WHAT IS CLAIMED IS:

1. A thermochromatic external liquid level gauge which is applied to the outside surface of the outside wall of a container, for use in the determination of the level of the interface between a mass of flowable material and the void volume above said mass of flowable material within said container, wherein said thermochromatic external liquid level gauge vertically extends along substantially the entire height of said container;

wherein said flowable material within said container has fluidic properties; and said flowable material has a faster rate of heat transfer than said void volume above it within said container;

wherein said thermochromatic external liquid level gauge is in intimate heat transfer relationship with said outside wall of said container;

wherein at least that portion of said outside surface which underlies said thermochromatic external liquid level gauge has light absorbing properties;

wherein said thermochromatic external liquid level gauge includes at least two thermochromatic materials;

wherein said at least two thermochromatic materials are directly applied to said outside surface of said outside wall of said container and are arranged in at least two regions;

wherein each of said at least two regions of thermochromatic materials is arranged in an individual area upon said outside surface of said outside wall of said container, and wherein each of said thermochromatic materials responds chromatically within a different operating temperature range;

wherein said regions of said at least two thermochromatic materials are disposed in arrays thereof arranged entirely along the length of said thermochromatic

external liquid level gauge in the vicinity between the bottom end of said gauge and the top end of said gauge;

wherein each of said at least two thermochromatic materials is directly applied to said outside surface of said outside wall of said container by an application method chosen from the group consisting of painting, silk screening, stencilling, molding, crayon transfer, pencil transfer, screening, and combinations thereof; and

wherein each of said at least two thermochromatic materials is carried to said outside surface of said outside wall of said container during said application method by a transfer medium.

2. The thermochromatic external liquid level gauge of claim 1, wherein at least said portion of said outside surface of said outside wall of said container which underlies said thermochromatic external liquid level gauge has been treated by an application method chosen from the group consisting of anodizing, anti-oxidizing, rust-proofing, and combinations thereof, so as to provide at least said portion of said outside surface of said outside wall with a light absorbing property, prior to the direct application of said thermochromatic external liquid level gauge to said outside surface of said outside wall of said container.

3. The thermochromatic external liquid level gauge of claim 1, wherein said flowable material is chosen from the group consisting of water, alcohol, oil, coffee, tea, juice, milk, liquefied gas, corrosive liquid and granular material.

4. The thermochromatic external liquid level gauge of claim 1, wherein said thermochromatic external liquid level gauge is directly applied to said outside surface of said outside wall of said container chosen from the group of containers consisting of pressurized cylinders, open containers, sealed containers, cryogenic flasks, and opaque

vessels, so as to determine the level of the interface between said mass of flowable material and said void volume above said mass of flowable material within said container to which said thermochromatic external liquid level gauge is directly applied.

5. The thermochromatic external liquid level gauge of claim 1, further including an ultraviolet filter layer, wherein said ultraviolet filter layer overlies said at least two thermochromatic materials.

6. The thermochromatic external liquid level gauge of claim 1, wherein said thermochromatic materials are chosen from the group of cholesteric liquid crystal compounds and mercurous oxide.

7. The thermochromatic external liquid level gauge of claim 1, wherein said at least two thermochromatic materials in said array have overlapping operating temperature ranges.

8. The thermochromatic external liquid level gauge of claim 1, wherein each of said thermochromatic materials in said array displays a color gradient within its operating temperature range.

9. The thermochromatic external liquid level gauge of claim 1, wherein each of said thermochromatic materials is arranged in said individual area chosen from the group of geometric configurations consisting of dots, circles, stars, squares, triangles, arrows, semi-circles, pentagons, hexagons, digits and letters.

10. The thermochromatic external liquid level gauge of claim 1, wherein said regions of thermochromatic materials are arranged on said outside surface of said outside

wall of said container chosen from the group of arrays consisting of one of said regions of thermochromatic materials vertically positioned down the center of said gauge and at least one other region diagonally positioned on each side of said vertically positioned region of said gauge, all of said regions of thermochromatic materials vertically positioned upon said gauge, all of said regions of thermochromatic materials diagonally positioned upon said gauge, and all of said regions of thermochromatic materials horizontally positioned upon said gauge.

11. The thermochromatic external liquid level gauge of claim 1, wherein said at least two adjacent regions of thermochromatic materials are arranged to form a set.

12. The thermochromatic external liquid level gauge of claim 11, wherein said set is disposed vertically along the entire length of said thermochromatic external liquid level gauge in a repeated manner.

13. A thermochromatic external liquid level gauge which is applied to the outside surface of the outside wall of a container, for use in the determination of the level of the interface between a mass of flowable material and the void volume above said mass of flowable material within said container, wherein said thermochromatic external liquid level gauge vertically extends along substantially the entire height of said container;

wherein said flowable material within said container has fluidic properties; and said flowable material has a faster rate of heat transfer than said void volume above it within said container;

wherein said thermochromatic external liquid level gauge is in intimate heat transfer relationship with said outside wall of said container;

wherein said thermochromatic external liquid level gauge includes a substrate and a series of indicia printed thereon, and wherein said substrate is directly applied to said outside surface of said outside wall of said container;

wherein said indicia are vertically positioned along the entire length of said substrate and at predetermined spaced-apart locations;

wherein said thermochromatic external liquid level gauge includes at least two thermochromatic materials;

wherein each of said at least two regions of thermochromatic materials is arranged in an individual area upon said substrate, and wherein each of said thermochromatic materials responds chromatically within a different operating temperature range;

wherein said regions of said at least two thermochromatic materials are disposed in arrays thereof arranged entirely along the length of said thermochromatic external liquid level gauge in the vicinity between the bottom end of said substrate and the top end of said substrate; and

wherein each of said at least two thermochromatic materials is applied to said substrate by an application method chosen from the group consisting of painting, silk screening, stencilling, molding, crayon transfer, pencil transfer, screening, and combinations thereof.

14. The thermochromatic external liquid level gauge of claim 13, wherein said series of indicia on said substrate underlie said at least two thermochromatic materials.

15. The thermochromatic external liquid level gauge of claim 13, wherein said substrate has light absorbing properties.

16. The thermochromatic external liquid level gauge of claim 13, wherein said indicia on said substrate remain invisible until such time when at least a portion of one of said at least two thermochromatic materials on said substrate, when placed on said outside surface of said outside wall of said container, becomes activated.

17. The thermochromatic external liquid level gauge of claim 16, wherein at least said portion of one of said at least two thermochromatic materials on said substrate, which is placed on said outside surface of said outside wall of said container, becomes translucent when activated, so as to reveal at least one of said indicia printed on said substrate.

18. The thermochromatic external liquid level gauge of claim 13, further including a protective clear lamina, wherein said protective clear lamina overlies said at least two thermochromatic materials.

19. The thermochromatic external liquid level gauge of claim 18, wherein said protective clear lamina is an ultraviolet filter.

20. A method of determining the level of the interface between a mass of flowable material and the void volume above said mass of flowable material within a container using a thermochromatic external liquid level gauge;

wherein said flowable material within said container has fluidic properties; and said flowable material has a faster rate of heat transfer than said void volume above it within said container;

wherein said thermochromatic external liquid level gauge is applied to said outside surface of said outside wall of said container;

wherein said thermochromatic external liquid level gauge vertically extends along substantially the entire height of said container;

wherein said thermochromatic external liquid level is in intimate heat transfer relationship with said outside wall of said container;

wherein at least that portion of said outside surface which underlies said thermochromatic external liquid level gauge has light absorbing properties;

wherein said thermochromatic external liquid level gauge includes at least two thermochromatic materials, and has an outer surface remote from said outside surface of said container;

wherein said at least two thermochromatic materials are directly applied to said outside surface of said outside wall of said container and are arranged in at least two regions;

wherein each of said at least two regions of thermochromatic materials is arranged in an individual area upon said outside surface of said outside wall of said container, and wherein each of said thermochromatic materials responds chromatically within a different temperature range;

wherein said regions of said at least two thermochromatic materials are disposed in arrays thereof arranged entirely along the length of said thermochromatic external liquid level gauge in the vicinity between the bottom end of said gauge and the top end of said gauge; and

wherein each of said at least two thermochromatic materials is carried to said outside surface of said outside wall of said container by a transfer medium;

said method comprising the steps of:

(i) inducing heat transfer between said thermochromatic external liquid level gauge and said mass of flowable material within said container;

(ii) discerning visually a color change in said at least one region of said array of said thermochromatic external liquid level gauge;

wherein said region which responds chromatically to a temperature change is contiguous to said mass of flowable material within said container;

wherein step (i) is achieved by any of the steps chosen from the group of steps consisting of:

(a) spraying a liquid onto said outer surface of said thermochromatic external liquid level gauge;

(b) wetting said outer surface surface of said thermochromatic external liquid level gauge, with a moistened cloth or sponge;

(c) pouring a liquid down said outer surface of said thermochromatic external liquid level gauge; and

(d) trickling a liquid down said outer surface of said thermochromatic external liquid level gauge.

21. The method of claim 20, wherein at least said portion of said outside surface of said outside wall of said container which underlies said thermochromatic external liquid level gauge has been treated by an application method chosen from the group consisting of anodizing, anti-oxidizing, rust-proofing, and combinations thereof, so as to provide at least said portion of said outside surface of said outside wall with a light absorbing property, prior to the direct application of said thermochromatic external liquid level gauge to said outside surface of said outside wall of said container.

22. The method of claim 20, wherein each of said at least two thermochromatic materials is directly applied to said outside wall of said container by an application method chosen from the group consisting of painting, silk screening, stencilling, molding, crayon transfer, pencil transfer, screening, and combinations thereof.

23. The method of claim 20, wherein said liquid in any of steps (a) through (d) is a heat source; and wherein said liquid is at a temperature which is above the temperature of said flowable material within said container so as to induce heat transfer from said liquid to said flowable material within said container.

24. The method of claim 20, wherein said liquid in any of steps (a) through (d) is a heat sink; and wherein said liquid is at a temperature which is below the temperature of said flowable material within said container so as to induce heat transfer to said liquid from said flowable material within said container.

25. The method of claim 20, wherein said at least two adjacent regions are arranged to form a set; said set comprises said at least two thermochromatic materials.

26. The method of claim 25, wherein said set is disposed vertically along the entire length of said thermochromatic external liquid level gauge in a repeated manner.

27. The method of claim 26, wherein said plurality of sets are disposed in a repeated manner vertically along the length of said thermochromatic external liquid level gauge, and said method further comprises the step of:

(iii) estimating the level of the interface between said mass of flowable material and said void volume above said mass of flowable material within said container using said thermochromatic external liquid level gauge; wherein the estimated area falls between a level having a profound color change and a level having a faint color change.

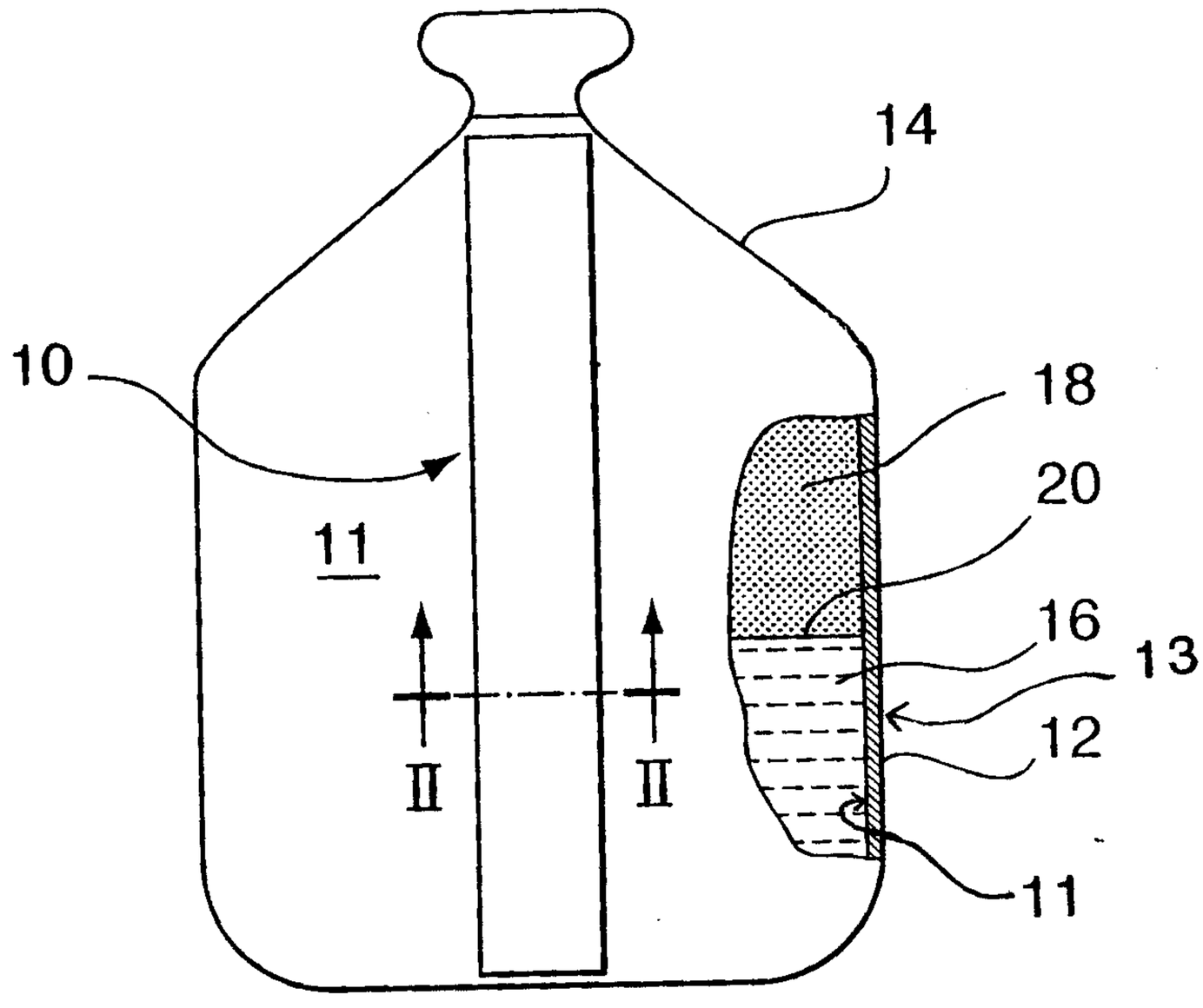


FIG. 1

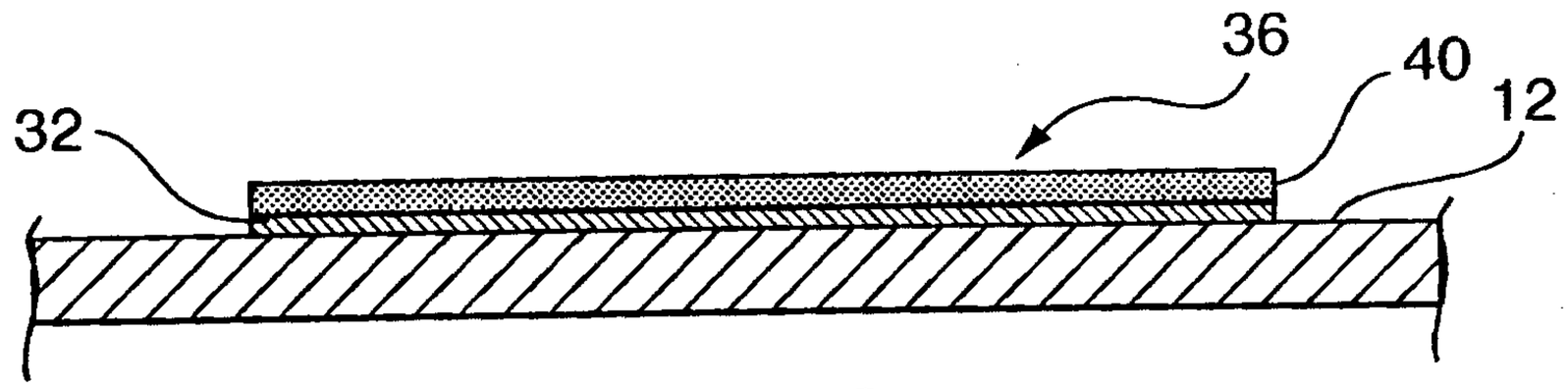


FIG. 2

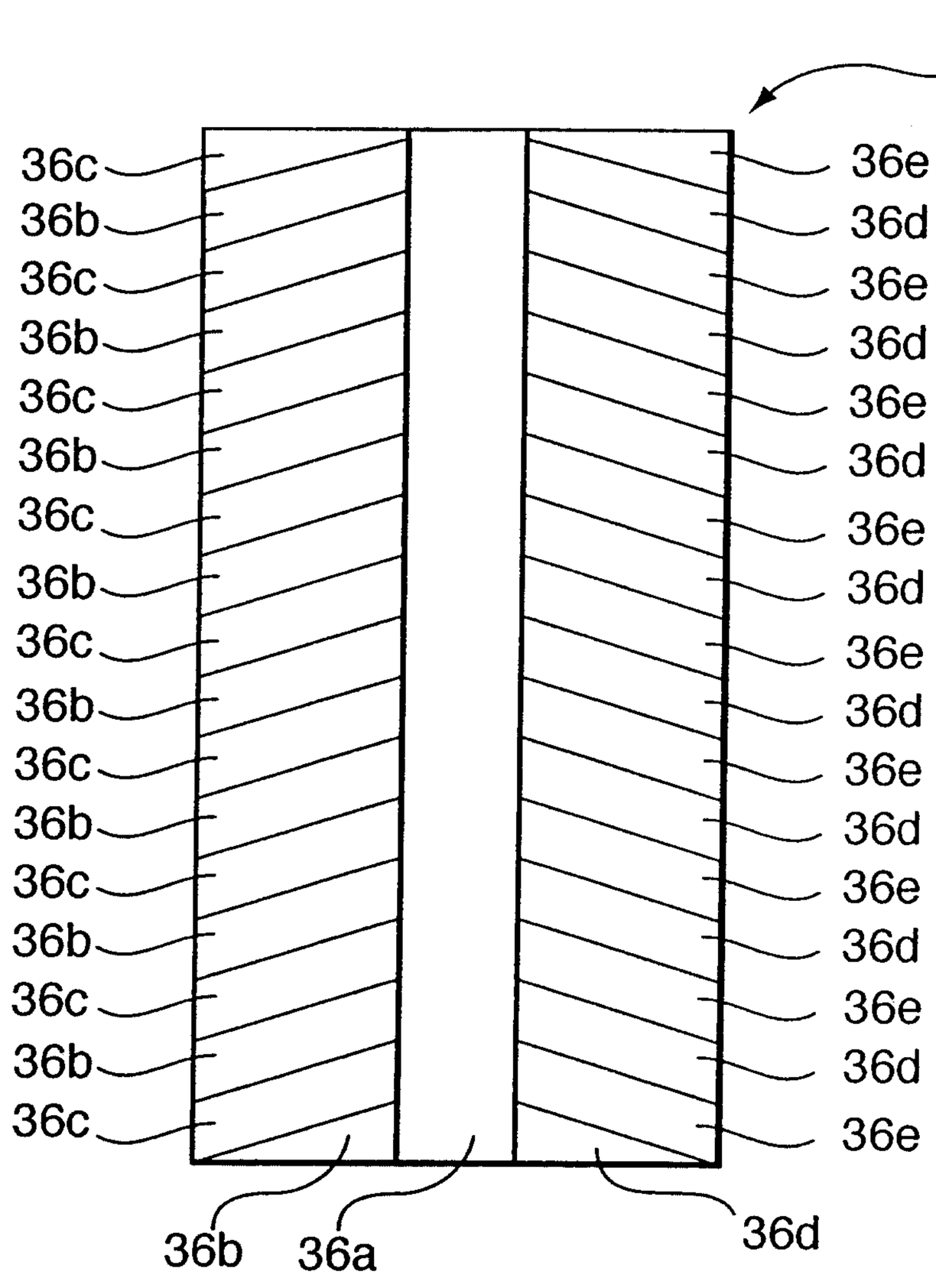

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FIG. 3

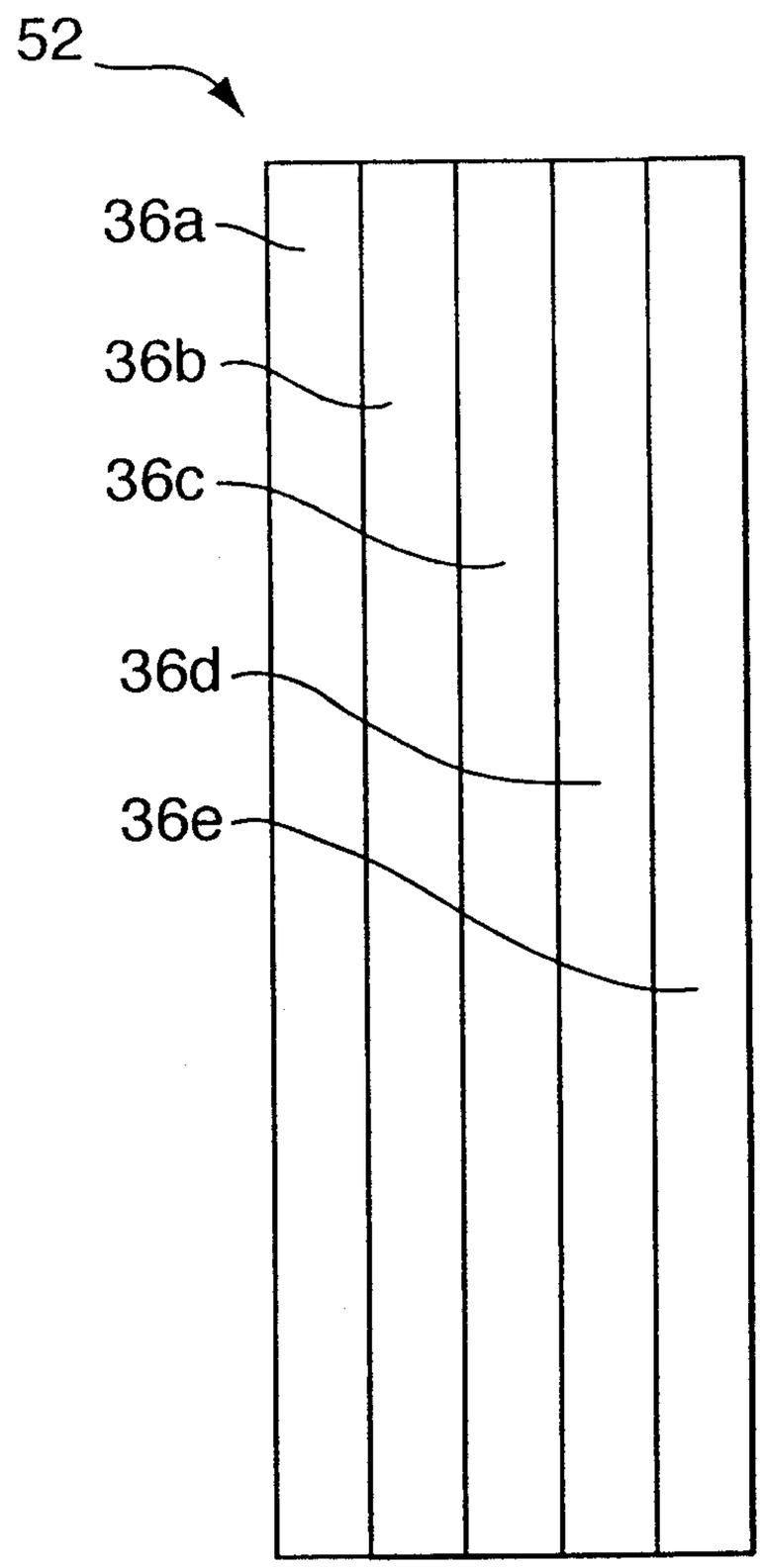


FIG. 4

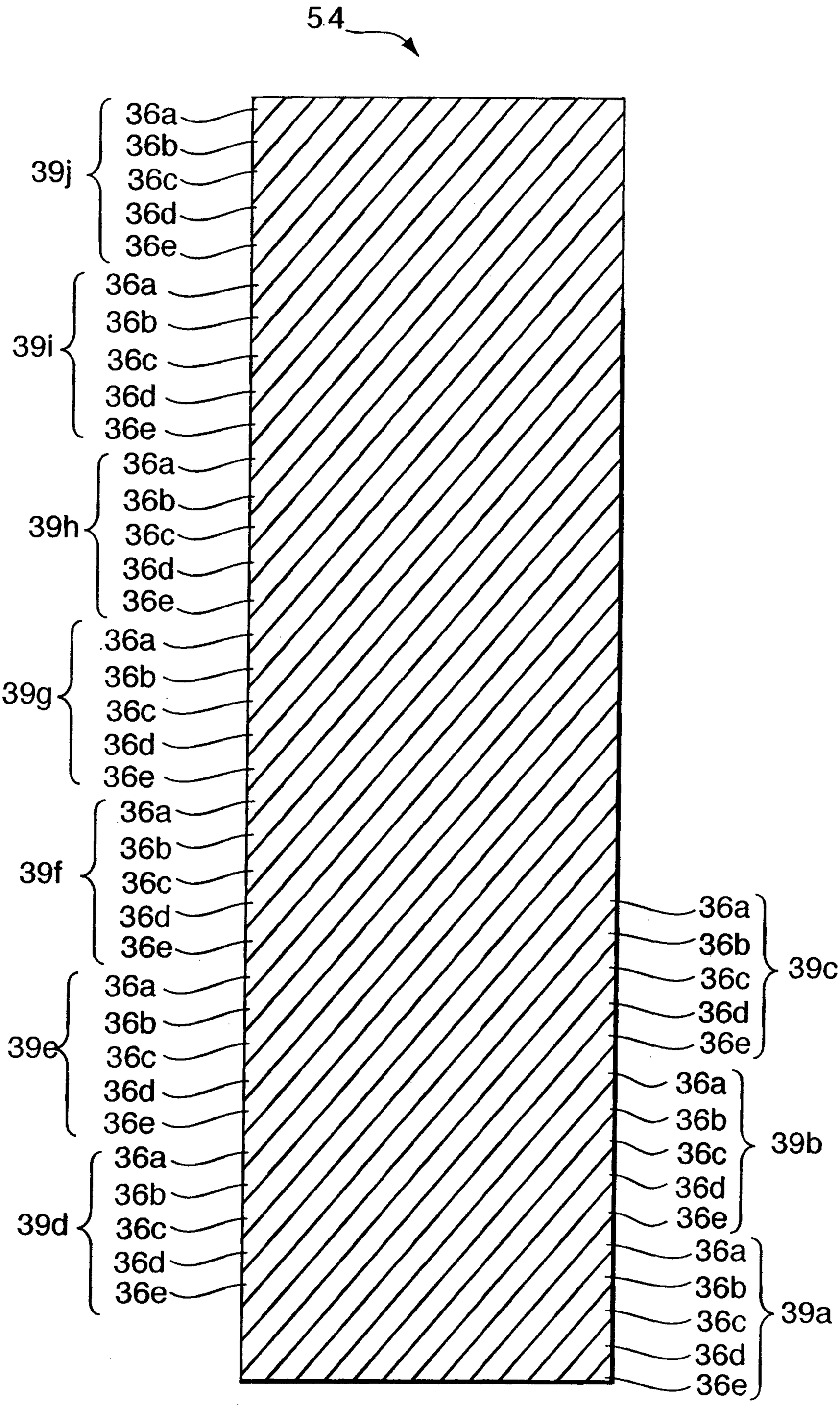

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FIG. 5

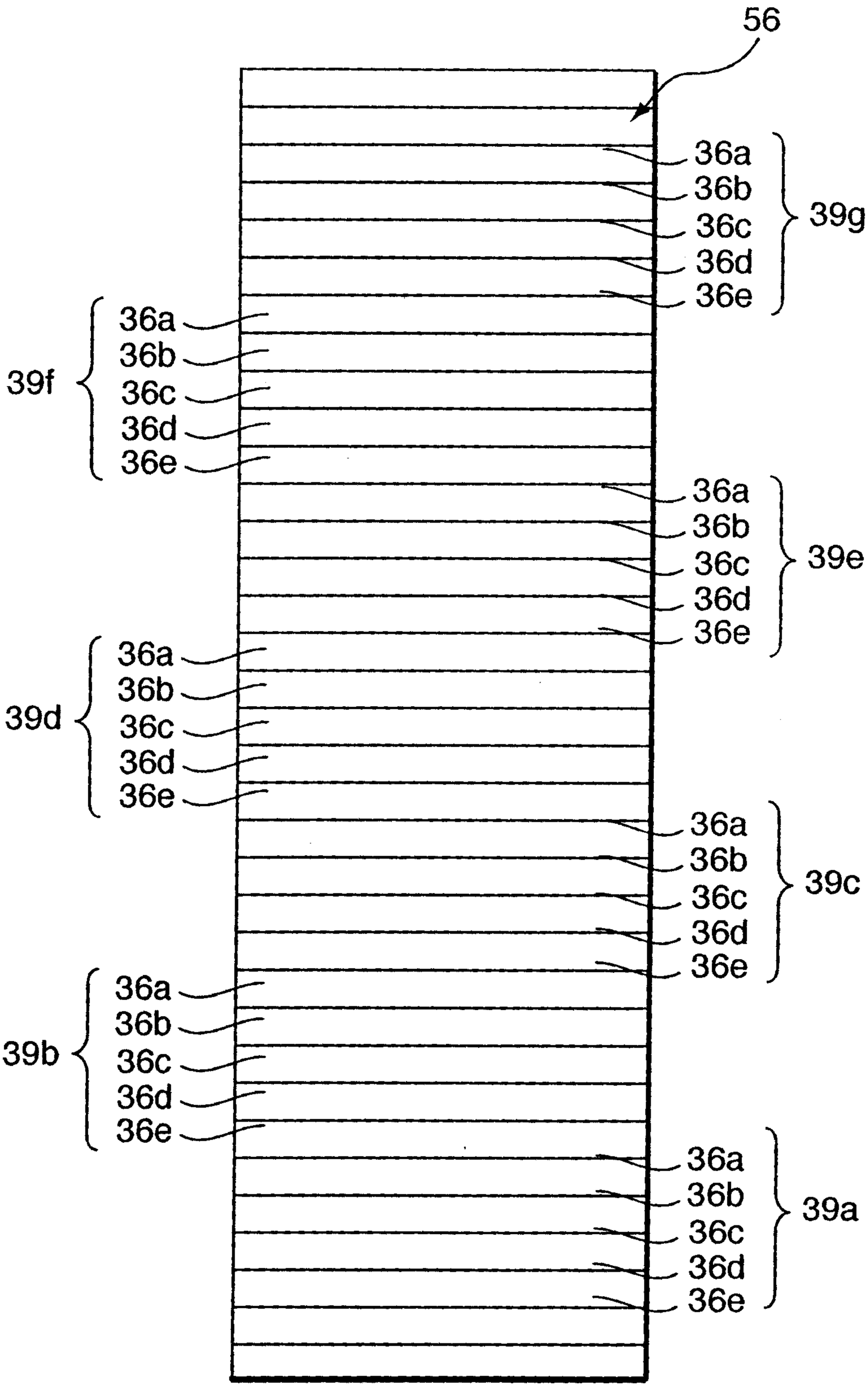

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FIG. 6

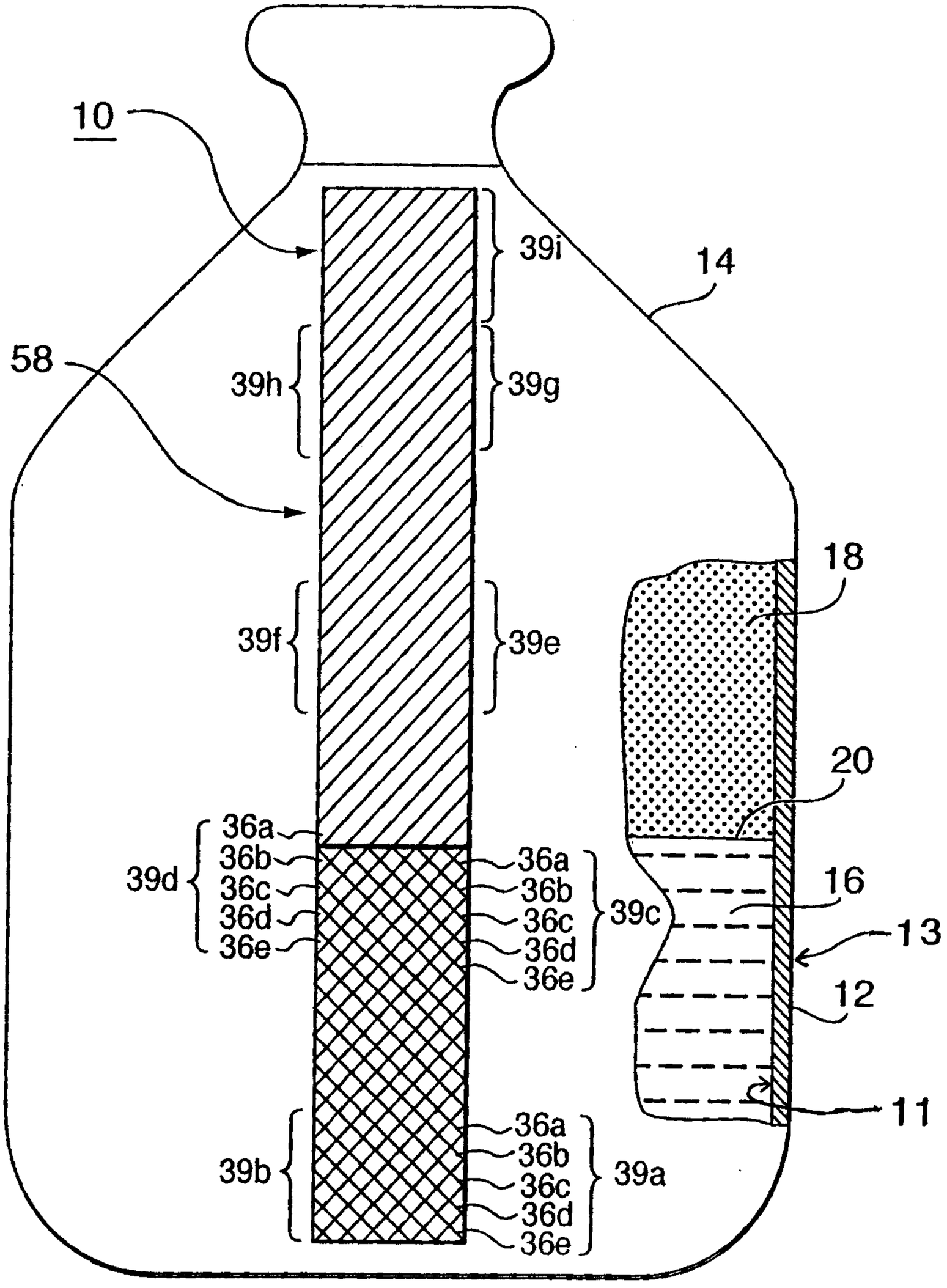

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FIG. 7

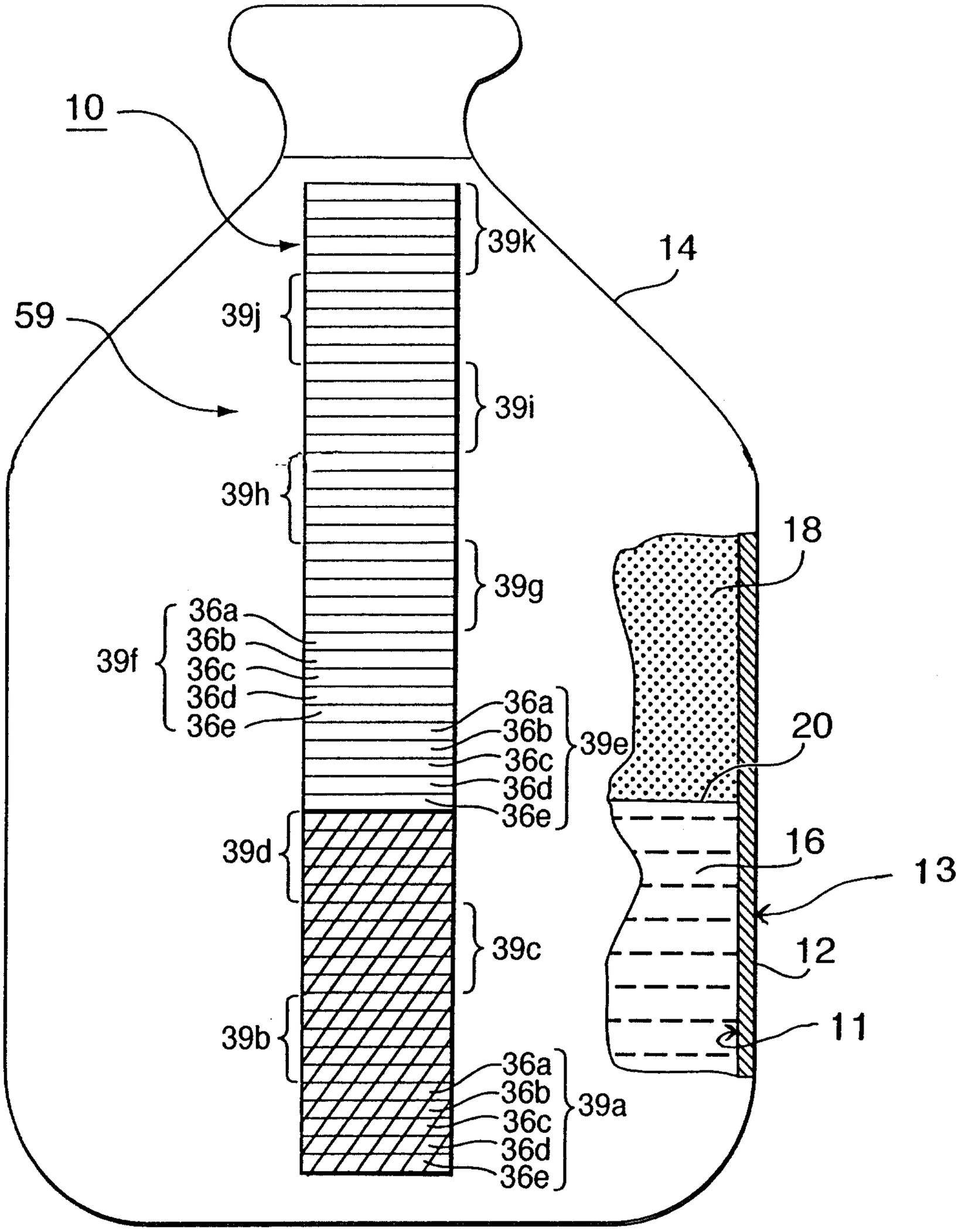

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39k
39j
39i
39h
39g
39f
39e
39d
39c
39b
39a
36a
36b
36c
36d
36e

FIG. 8

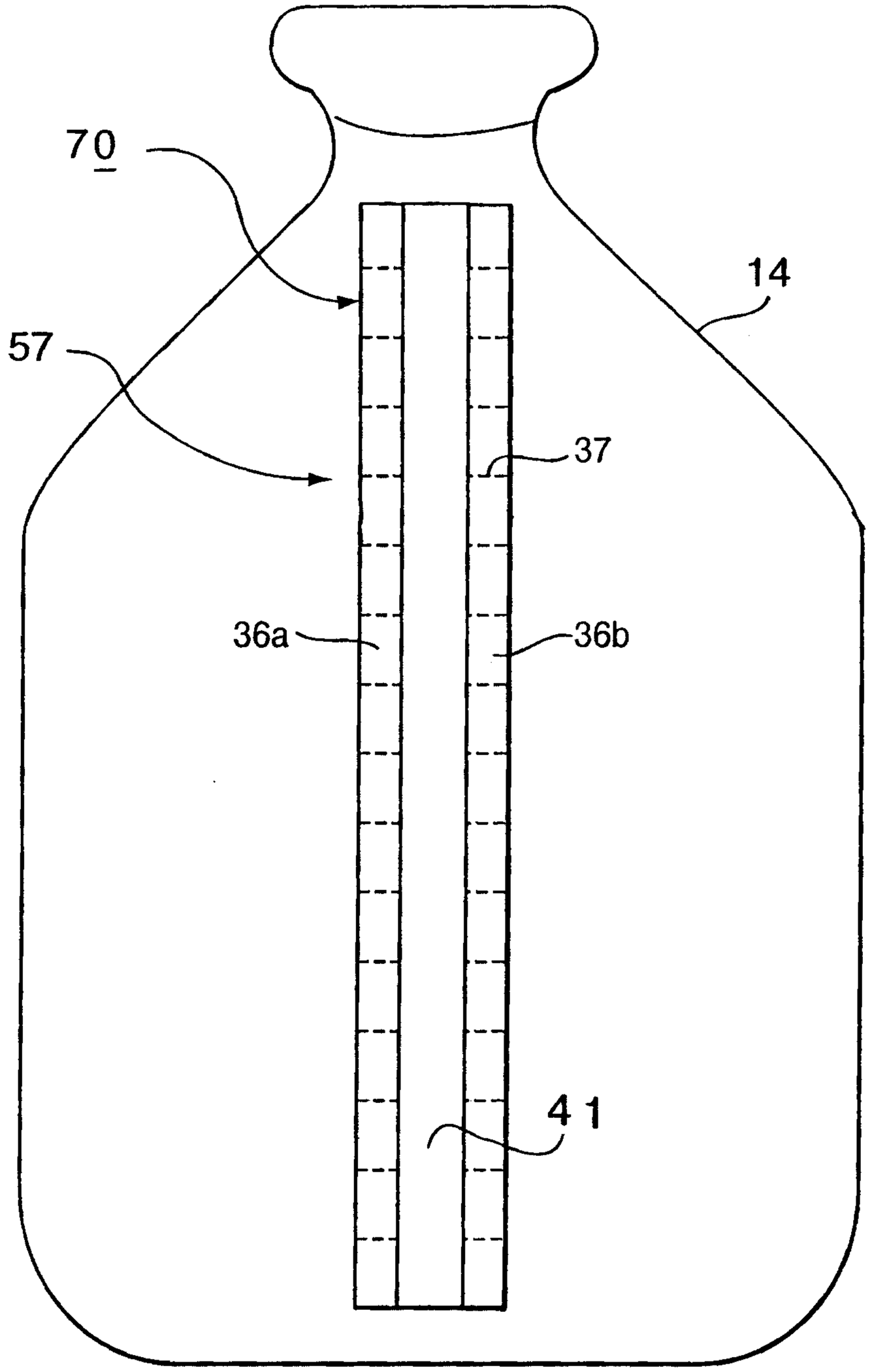
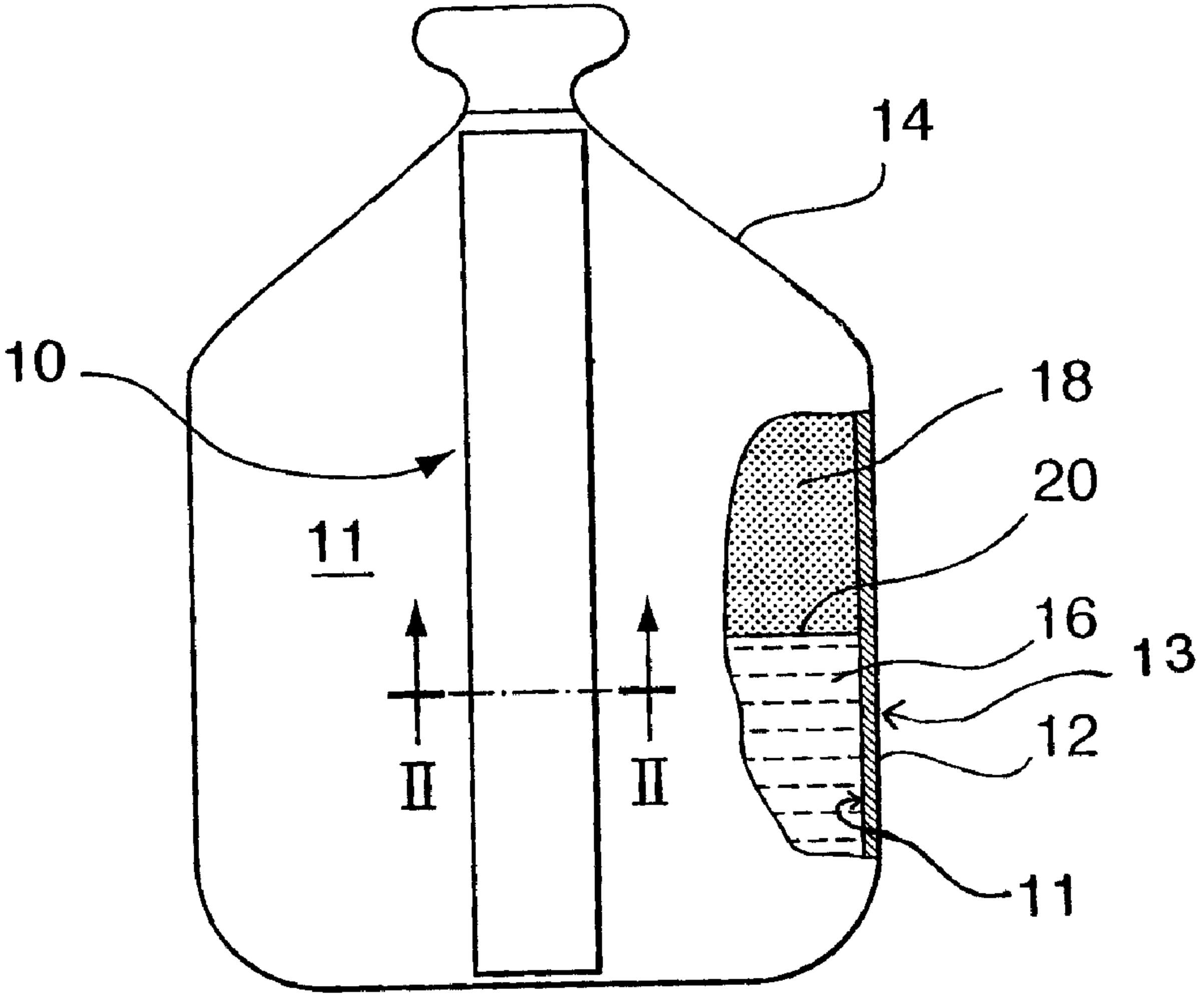


FIG. 9


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II
II
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