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(71) Applicant: **Tetra Laval Holdings & Finance S.A.**
1009 Pully (CH)

(72) Inventor: **BOZZOLI, Valerio**
41123 Modena (IT)

(74) Representative: **Tetra Pak - Patent Attorneys SE**
AB Tetra Pak
Patent Department
Ruben Rausings gata
221 86 Lund (SE)

(54) INSPECTION APPARATUS FOR A CAPPING MACHINE, RESPECTIVE CAPPING MACHINE AND PACKAGING PLANT

(57) There is described an inspection apparatus (20) for inspecting caps (12; 12') applied to main bodies (4) of respective packages (2). The inspection apparatus (20) comprises an imaging device configured to acquire at least one image (21) and an analyzing unit configured to analyze each image (21) and to determine an orientation of the cap (12; 12') with respect to a reference line (25) of the respective main body (4). The analyzing unit is configured to determine from each image (21) at least one first reference point (26) of at least one auxiliary portion (11, 11') of the respective cap (12, 12') and to obtain a linear line (27) between the determined first reference point (26) and a second reference point (28) of the cap (12; 12'). The analyzing unit is also configured to determine an orientation angle between the linear line (27) with respect to the reference line (25), the orientation angle describing the orientation of the cap (12; 12') with respect to the main body (4).

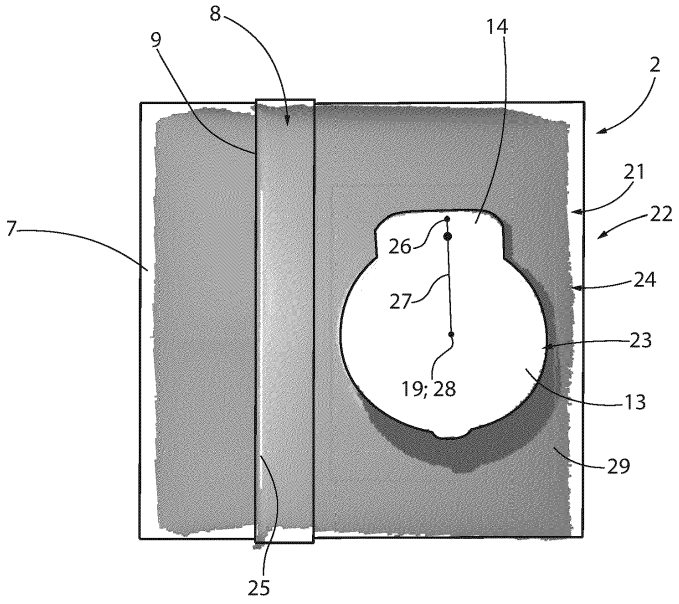

FIG.2

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Description

TECHNICAL FIELD

[0001] The present invention relates to an inspection apparatus for a capping machine.

[0002] Advantageously, the present invention also relates to a capping machine for applying caps onto main bodies of packages filled with a pourable product, preferentially packages formed from a multilayer packaging material.

[0003] Advantageously, the present invention also relates to a packaging plant for the packaging of pourable products, preferentially pourable food products, into packages, preferentially packages formed from a multilayer packaging material, and having at least one capping machine.

[0004] Advantageously, the present invention also relates to a method of inspecting packages having caps applied to respective main bodies.

[0005] Advantageously, the present invention also relates to a method of applying caps onto main bodies of packages.

BACKGROUND ART

[0006] As is known, many liquid or pourable food products, such as fruit juice, UHT (ultra-high-temperature treated) milk, wine, tomato sauce, etc., are sold in packages, in particular sealed packages, made of sterilized packaging material.

[0007] A typical example is the parallelepiped-shaped package for pourable food products known as Tetra Brik Aseptic (registered trademark), which is made by sealing and folding a laminated strip packaging material. The packaging material has a multilayer structure comprising a carton and/or paper base layer, covered on both sides with layers of heat-seal plastic material, e.g. polyethylene. In the case of aseptic packages for long-storage products, the packaging material also comprises a layer of oxygen-barrier material, e.g. an aluminum foil, which is superimposed on a layer of heat-seal plastic material, and is in turn covered with another layer of heat-seal plastic material forming the inner face of the package eventually contacting the food product.

[0008] Packages of this sort are normally produced on fully automatic packaging plants, which form and fill the packages starting from a multilayer packaging material.

[0009] Some packaging plants are configured to produce packages comprising a main body formed from the multilayer packaging material and an opening device arranged about a pour opening of the main body. The opening device is configured to allow for selectively opening and closing the pouring outlet.

[0010] A typical opening device comprises a collar arranged about the pouring outlet and a cap secured to the collar and being controllable between a closing position and an opening position.

[0011] A typical packaging plant for producing packages having a respective opening device comprises a package forming machine configured to form and fill at least the respective main bodies from the multilayer packaging material and a capping machine configured to apply at least the cap to the respective main body.

[0012] According to one possible embodiment, the package forming machine may be configured to produce packages having both the respective main body formed form the multilayer packaging material and a collar arranged about the respective pouring outlet. The capping machine is configured to apply and secure the cap onto the collar.

[0013] The correct application of the cap onto the main body is important so as to guarantee a correct functioning.

[0014] The cap may be connected to a membrane, which covers an outpouring hole of the main body. During a first-time movement of the cap from a closed position to an open position, the membrane needs to be removed. If the cap is not correctly applied, the removal of the membrane may fail.

[0015] Therefore, some capping machines are provided with an inspection unit configured to determine a correct application of the caps. The inspection unit operates by monitoring the center position of the cap with respect to the main body.

[0016] Even though the known inspection apparatuses and/or capping machines and/or packaging plants operate satisfyingly well, a desire for further improvements is felt in the sector.

DISCLOSURE OF INVENTION

[0017] It is therefore an object of the present invention to provide an improved inspection apparatus.

[0018] It is therefore another object of the present invention to provide an improved capping machine.

[0019] It is a further object of the present invention to provide an improved packaging plant.

[0020] It is an even further object of the present invention, to provide an improved method of inspection.

[0021] Moreover, it is an object of the present invention, to provide an improved method of applying caps.

[0022] According to the present invention, there are provided an inspection apparatus and a method for inspecting the application of caps according to the respective independent claims.

[0023] Preferred embodiments of the inspection apparatus and the method are claimed in the claims being directly or indirectly dependent on the respective independent claims.

[0024] According to the present inventions, there is also provided a capping machine according to claim 8.

[0025] According to the present invention, there is also provided a packaging plant according to claim 9.

[0026] According to the present invention, there is also provided a method according to claim 17.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] Two non-limiting embodiments of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a packaging plant having at least one capping machine, with parts removed for clarity;

Figure 2 is an image of a portion of a package, with parts removed for clarity;

Figures 3A to 3C are schematic top views of a cap of a first type and illustrate the steps of analyzing the image of Figure 2, with parts remove for clarity;

Figure 4 is a schematic top view of a cap of a second type and illustrates a step during assessment of a respective image, with parts removed for clarity; and

Figure 5 is a schematic top view of the cap of Figure 4 and during a final step of assessment, with parts removed for clarity.

BEST MODES FOR CARRYING OUT THE INVENTION

[0028] Number 1 indicates as a whole a packaging plant for producing packages 2 filled with a pourable product, in particular a pourable food product, such as (pasteurized) milk, fruit juice, wine, tomato sauce, salt, sugar, emulsions, yoghurt, milk drinks etc.

[0029] Packaging plant 1 may be configured to produce packages 2 filled with the pourable product.

[0030] In more detail, packaging plant 1 may be configured to produce packages 2 from a packaging material having a multilayer configuration.

[0031] In further detail, the packaging material may comprise at least one layer of fibrous material, such as e.g. a paper or cardboard, and at least two layers of heat-seal plastic material, e.g. polyethylene, interposing the layer of fibrous material in between one another. One of these two layers of heat-seal plastic material may define the inner face of package 2 contacting the pourable product.

[0032] Moreover, the packaging material may also comprise a layer of gas- and light-barrier material, e.g. aluminum foil or ethylene vinyl alcohol (EVOH) film, in particular being arranged between one of the layers of the heat-seal plastic material and the layer of fibrous material. Preferentially, the packaging material may also comprise a further layer of heat-seal plastic material being interposed between the layer of gas- and light-barrier material and the layer of fibrous material.

[0033] In further detail, the packaging material may be provided in the form of a web 3.

[0034] With particular reference to Figures 1 to 4, each package 2 may comprise a respective main body 4 formed from the multilayer packaging material and an opening device 5 arranged about a pour opening (not shown) of the respective main body 4.

[0035] In more detail, main body 4 may extend along a longitudinal axis A, a first transversal axis B perpendicular to longitudinal axis A and a second transversal axis C perpendicular to first transversal axis B and longitudinal axis A. Preferentially, the size of package 2 along longitudinal axis A may be larger than the size of package 2 along first transversal axis B and second transversal axis C.

[0036] Preferentially, main body 4 may be parallelepiped-shaped.

[0037] According to some preferred non-limiting embodiments, main body 4 may comprise a first wall, preferentially being transversal, more preferentially perpendicular, to longitudinal axis A, from which main body 4 may extend along longitudinal axis A. More specifically, the first wall may define a support surface of package 2, preferentially main body 4, which may be designed to be put in contact with a support, such as e.g. a shelf, when, in use, being e.g. exposed within a sales point or when being stored.

[0038] The first wall may define a bottom wall of package 2, in particular main body 4.

[0039] Preferentially, main body 4 may also comprise a side wall 6 being (fixedly) connected to first wall and extending, along longitudinal axis A, from first wall.

[0040] Preferentially, main body 4 may also comprise a second wall 7 opposite to first wall and being (fixedly) connected to side wall 6.

[0041] Preferentially, side wall 6 may be interposed between and integrally connected to the first wall and second wall 7.

[0042] Preferentially, second wall 7 may define a top wall of package 2.

[0043] According to the shown non-limiting embodiment, the first wall and second wall 7 may be parallel with respect to one another.

[0044] According to some other possible embodiments not shown, second wall 7 and the first wall may be inclined with respect to one another, more specifically second wall 7 may be inclined with respect to the first wall and/or longitudinal axis A.

[0045] According to some non-limiting embodiments, second wall 7 may carry and/or comprise the designated pour opening and opening device 5 may be connected to second wall 7.

[0046] According to some possible embodiments, each pour opening may be covered by a separation membrane, the separation membrane being preferentially formed from portions of the multilayer packaging material.

[0047] In further detail, each main body 4 may comprise one or more transversal seals 8.

[0048] More specifically, each second wall 7 may comprise one respective transversal seal 8.

[0049] Additionally, also each first wall may comprise one respective transversal seal (not visible).

[0050] According to some possible embodiments, transversal seals 8 may be (substantially) parallel to first

transversal axis B.

[0051] In further detail, each transversal seal 8 may (substantially) linearly extend (i.e. each transversal seal 8 has a (substantially) linear shape).

[0052] Moreover, each transversal seal 8 may have a linear edge 10, more specifically being parallel to first transversal axis B.

[0053] According to some possible embodiments, each main body 4 may also comprise a longitudinal seal 10. More specifically, each longitudinal seal 10 may be (substantially) perpendicular to the respective transversal seals 8.

[0054] With particular reference to Figures 2 to 3C, each opening device 5 may comprise a collar 11 protruding from the respective main body 4, preferentially second wall 7, and being arranged about the respective pour opening. Preferentially, each collar 11 may comprise a respective outlet opening configured to allow for the outpouring of the pourable product.

[0055] Moreover, each collar 11 may be spaced apart from the respective transversal seal 8 of the respective second wall 7.

[0056] Each opening device 5 may also comprise a cap 12 secured onto collar 11, and more specifically may be configured to selectively open and close the respective outlet opening.

[0057] In more detail, each collar 11 may include an outer projection and each cap 12 may comprise an inner projection, configured to engage with the outer projection of the respective collar 11 for securing cap 12 on collar 11.

[0058] By securing cap 12 onto collar 11 one arranged cap 12 onto main body 4.

[0059] In further detail, each cap 12 may be controllable between a respective closing position at which cap 12 closes the outlet opening (for impeding the outflow of the pourable product) and an opening position at which cap 12 frees the outlet opening (for allowing the outflow of the pourable product). Preferentially, each cap 12 is secured to the respective package 2 and is in the closing position when being delivered to an end user.

[0060] Advantageously, each cap 12 may be (repeatably) moveable between the respective closing position and the respective opening position.

[0061] According to the embodiment of Figures 2 to 3C, each cap 12 may be controllable between the respective closing position and the respective opening position by means of an angular movement about a hinge axis (transversal to longitudinal axis A). In such an embodiment, cap 12 is non-detachably connected to collar 11 in order to avoid that cap 12 is dispersed in the environment.

[0062] Moreover, each cap 12 may comprise a principal wall 13 configured to cover the outlet opening, in particular with cap 12 being in the closing position.

[0063] Advantageously, principal wall 13 may have a (substantially) circular shape.

[0064] Each cap 12 may also comprise an auxiliary portion protruding, more specifically radially protruding, from the respective principal wall 11. In particular, the auxiliary portion may be configured to be engaged by a user so as to at least facilitate control of the respective cap 12 from the respective closing position to the respective opening position.

[0065] In the specific embodiment of Figures 2 to 3C, the auxiliary portion may comprise and/or consist of an opening lip 14 and being configured to facilitate control of cap 12 from the closing position to the opening position. In particular, in use, opening lip 14 may be engaged by a user so as to exert an opening force on the respective cap 12.

[0066] In particular, the auxiliary portion; i.e. in the embodiment of Figures 2 to 3C opening lip 14, deviates from the circular shape of principal wall 13.

[0067] More specifically, principal wall 13 may comprise an outer edge defining and/or following a first circle 15 having a first diameter d1.

[0068] The auxiliary portion extends from first circle 15.

[0069] In further detail, each cap 12, more specifically the respective principal wall 13, may comprise a center 19 and a central axis extending through center 19.

[0070] In particular, the auxiliary protrusion, i.e. opening lip 14 of the embodiment of Figures 2 to 3C, extends between a first angular position and a second angular position with respect to the central axis.

[0071] Additionally, each cap 12 may comprise a lateral wall protruding from the respective principal wall 13 and being configured to surround at least a portion of the respective collar 11, in particular with cap 12 being in the closing position; i.e. each lateral wall surrounds the respective portion of collar 11 after cap 12 has been secured onto the respective collar 11.

[0072] According to some possible embodiments, each opening device 5 may also comprise a respective coupling element connected to and protruding from the respective separation membrane. Preferentially, each coupling element may be also connected to, preferentially sealed to, the respective cap 12. In particular, during a first-time control of the respective cap 12 into the respective opening position, the coupling element follows movement of the respective cap 12 leading to a detachment of the respective separation membrane from the respective main body 4.

[0073] More specifically, each coupling element may be surrounded by the respective collar 11. Even more specifically, each coupling element may comprise a portion protruding out of collar 11 and this portion may be sealed to cap 12.

[0074] According to some preferred non-limiting embodiments, each opening device 5 may also comprise a base frame carrying the respective collar 11 and being connected to, more specifically molded onto or bonded or adhesively bonded or glued to, the respective main body 4.

[0075] Advantageously, each collar 11 may be integral to the respective base frame and/or may extend from the respective base frame.

[0076] In further detail, each collar 11 may extend

along a respective central axis.

[0077] Moreover, each collar 11 may have an annular shape. More specifically, each collar 11 may have a circular shape.

[0078] According to some preferred non-limiting embodiments, each collar 11 may be molded to the respective main body 4, more specifically the respective second wall 7. For example, each collar 11 may be molded to web of packaging material 3 prior to forming and filling packages 2, more specifically main body 4.

[0079] More specifically, each collar 11 may be molded onto the respective main body 4 together with the respective base frame. Even more specifically, each collar 11 may be molded onto web of packaging material 3 together with the respective base frame prior to forming and filling packages 2, preferentially main body 4.

[0080] Additionally, also each coupling element may be molded to the respective main body 4, more specifically to web of packaging material 3 prior of forming and filling packages 2, preferentially main body 4.

[0081] With particular reference to Figure 1, packaging plant 1 may comprise:

- a package filling apparatus 17 configured to form and fill packages 2, in particular configured to form packages 2 from the multilayer packaging material and to fill packages 2 with the pourable product; and
- at least one capping machine 18configured to at least apply one respective cap 12 to each main body 4, more specifically onto the respective collar 11 protruding from main body 4.

[0082] In more detail, capping machine 18 may be arranged downstream from package filling apparatus 17 and may be configured to receive formed and filled packages 2 from package filling apparatus 17.

[0083] Please note that for reasons of simplicity, in the present description, when discussing operation of capping machine 18, we do not use different terms to indicate packages 2 which still need to receive the respective caps 12 and which have the respective caps 12. We consider that such differences are directly understandable from the description.

[0084] With particular reference to Figure 1, capping machine 18 comprises:

- a conveying device configured to advance packages 2 along and advancement path; and
- a cap application device configured to apply one respective cap 12 onto each collar 11.

[0085] In further detail, the cap application device may be configured to apply caps 12 onto the respective collars 9, but after application these are not yet fully secured onto the respective collars 11.

[0086] In more detail, in use, after operation of the cap application device each cap 12 may be only partially coupled to the respective collar 11.

[0087] Therefore, more specifically, capping machine 18 may also comprise one or more cap securing devices configured to secure caps 12 onto the respective collars 8. E.g. each cap securing device may be configured to screw and/or push caps 12 onto the respective collars 8.

[0088] More specifically, each cap securing device ensures, in use, that each cap 12 may be fully coupled to the respective collar 11.

[0089] In more detail, the cap securing devices may be arranged downstream from the cap application device along the advancement path.

[0090] According to some possible embodiments, capping machine 18 may comprise only one cap securing device. Alternatively, capping machine 18 may comprise more than one cap securing device configured to simultaneously secure respective caps 12 onto the respective collars 8.

[0091] According to some possible non-limiting embodiments, capping machine 18 may also comprise one or more cap sealing devices configured to seal the respective coupling elements to the respective caps 12.

[0092] More specifically, the cap sealing devices may be arranged downstream from the cap securing device(s) along the advancement path.

[0093] According to some possible embodiments, capping machine 18 may comprise only one cap sealing device. Alternatively, capping machine 18 may comprise more than one cap sealing device configured to simultaneously seal the respective coupling elements to the respective caps 12.

[0094] With particular reference to Figure 1, capping machine 18 may comprise an inspection apparatus 20 configured to inspect caps 12 with respect to the respective main bodies 4.

[0095] More specifically, inspection apparatus 20 may be configured to determine an orientation of caps 12 with respect to the respective main bodies 4, in particular the respective transversal seal 8 of the respective second wall 7.

[0096] In particular, inspection apparatus 20 may be configured to determine on whether caps 12 present an orientation, which allows a correct functioning of caps 12.

[0097] More particular, a correctly oriented cap 12 guarantees that the user can move the respective cap 12 from the respective closing position to the respective opening position. Additionally, a correctly oriented cap 12 may guarantee that during movement of the respective cap 12 from the closing position to the opening position, the separation membrane correctly detaches.

[0098] In more detail, inspection apparatus 20 may be arranged downstream from the cap application device and/or the cap securing device(s) along the advancement path.

[0099] More specifically, inspection apparatus 20 may also be arranged downstream from the cap sealing device(s) along the advancement path.

[0100] In more detail, inspection apparatus 20 comprises an imaging device configured to acquire at least

one image 21 per package 2 of an inspection portion 22 of package 2.

[0101] Advantageously, the imaging device may be configured to acquire exactly one image 21 per package 2.

[0102] More specifically, the imaging device may be, during the acquisition, be arranged above the respective package 2.

[0103] In more detail, each image 21 is acquired in a direction (substantially) perpendicular to the respective second wall 7 and/or the respective principal wall 13.

[0104] According to some possible embodiments, the imaging device comprises and/or is a 3D camera, specifically a digital video camera, more specifically a 3D digital video camera, configured to acquire images 21. Preferentially, the imaging device is configured acquire a three-dimensional image 21 of the package 2.

[0105] E.g. the imaging device may be configured to execute a 3D profiling (laser triangulation).

[0106] As shown in Figures 2 to 3C, inspection portion 22 may have a portion of the respective main body 4, more specifically the respective second wall 7, and cap 12.

[0107] In more detail (see Figure 2), each acquired image 21 may be a pixel image. Thereby a first set 23 of pixels (indicated in white color) represents and/or corresponds to cap 12 and, in particular a second set 24 of pixels (indicated in grey color) represents and/or corresponds to second wall 7.

[0108] Moreover, each first set 23 of pixels and the respective second set 24 of pixels are spaced apart from one another along a first direction, more specifically being (substantially) perpendicular to, second wall 7.

[0109] In particular, the imaging device allows to acquire a 3D image; in other words, each image 21 is a three-dimensional image.

[0110] Inspection apparatus 20 may also comprise an analyzing unit configured to analyze each image 21 and to determine the orientation of each cap 12 with respect to main body 2, more specifically second wall 7, even more specifically the respective transversal seal 8 of second wall 7.

[0111] In more detail, the analyzing unit is configured to analyze each image 21 and to determine the orientation of cap 12 with respect to a reference line 25 of the respective main body 4, more specifically of the respective second wall 7.

[0112] More specifically, the analyzing unit may be configured to define reference line 25 such that reference line 25 may be parallel to and/or may extend along the respective transversal seal 8 (of second wall 7).

[0113] Even more specifically, the analyzing unit may be configured to define a respective edge 9 of transversal seal 8 as the respective reference line 25.

[0114] The analyzing unit is configured to determine from each image 21 at least one first reference point 26 of the at least one auxiliary portion, i.e. in the specific embodiment of Figures 2 to 3C of the respective opening lip 14 and to obtain a linear line 27 between the respective determined first reference point 26 and a second reference point 28 of cap 12, in the specific case shown in Figures 2 to 3C of the respective principal wall 13.

[0115] In the specific case shown in Figures 2 to 3C, the analyzing unit may be configured to define the respective center 19 of the respective principal wall 13 as the respective second reference point 28.

[0116] Each linear line 27 is indicative about the orientation of cap 12. Therefore, the analyzing unit is configured to determine an orientation angle between each linear line 27 with respect to the respective reference line 25. In particular, it is the orientation angle, which describes the orientation of cap 12 with respect to main body 4.

[0117] In particular, the orientation angle describes the relative orientation between each linear line 27 with respect to the respective reference line 25.

[0118] It should be noted that the orientation angle may be expressed in quantitative or in qualitative means.

[0119] In more detail, the orientation angle can be determined under consideration of respective imaginary lines, which extend from linear line 27 and reference line 25 and the respective intersection between the respective imaginary lines. Alternatively, the analysis unit can be configured to change the relative positions of each linear line 27 and the respective reference line 25 with respect to one another and along a direction perpendicular to the respective reference line 25 until the respective linear line 27 and the respective reference line 25 intersect.

[0120] In theory (i.e. if the cap 12 is perfectly applied), each cap 12 should be aligned such that the respective linear line 27 is parallel to the respective reference line 25. In such a case, linear line 27 and the respective reference line 25 do not intersect. According to such a case, one can attribute an angle of 0° to linear line 27.

[0121] In practice, each cap 12 may deviate from the theoretical orientation and each linear line 27 and the respective reference line 25 may intersect.

[0122] According to some non-limiting embodiments, the analyzing unit may be configured such to determine a correct orientation of cap 12 if the respective orientation angle lies within a pre-determined range and/or to determine an incorrect orientation if the respective orientation angle lies outside from the pre-determined range.

[0123] In further detail, the analyzing unit may be configured to determine each reference line 25 from (i.e. on the basis of) the respective transversal seal 8 of the respective main body 4, more specifically of the respective second wall 7, from the respective image 21. In particular, the analyzing unit may be configured such that each reference line 25 is parallel to the respective transversal seal 8.

[0124] More specifically, the analyzing unit may be configured to align the respective reference line 25 along the respective transversal seal 8.

[0125] In even more detail, the analyzing unit may be configured to determine the respective transversal seal 8

from the respective second set 24 of pixels and thereby to also determine the respective reference line 25 from the respective second set 24 of pixels.

[0126] More specifically, the analyzing unit may be configured to divide the second set 24 of pixels into a first sub-set corresponding to a base of the respective second wall 7 and a second sub-set corresponding to the respective transversal seal 8, the respective transversal seal 8 extends from the respective base 29. In particular, the analyzing unit may be configured to identify the respective second sub-set of pixels as these are distanced from the respective first sub-set of pixels.

[0127] Moreover, each second sub-set of pixels is interposed between the respective first sub-set of pixels and the respective first set 23 of pixels.

[0128] According to some non-limiting embodiments, the analyzing unit may be configured to calculate each first reference point 26 based on the respective first set 23 of pixels.

[0129] More specifically and with particular reference to Figures 3A and 3B, the analyzing unit may be configured to fit at least one circle 30 having a diameter d2 larger than the respective diameter d1 and first circle 30 having an arc-shaped profile portion 31 extending within the respective auxiliary portion (i.e. circle 30 has a radius less than a radius of the arc-shaped profile portion 31); i.e. the respective opening lip 14 when considering the embodiment of Figures 2 to 3C.

[0130] More specifically, the analyzing unit may be configured to fit each circle 30 based on the respective first set 23 of pixels. Even more specifically, each arc-shaped profile portion 31 may be based on the respective pixels of the respective first set 23 of pixels being associated to the respective auxiliary portion; i.e. the respective opening lip 14 when considering the embodiment of Figures 2 to 3C.

[0131] Moreover, the analyzing unit may be configured to calculate the respective first reference point 26 from the respective arc-shaped profile portion 31.

[0132] More specifically, the analyzing unit may be configured to determine and/or estimate a profile center of each arc-shaped profile portion 31 and the respective profile center defining the respective first reference point 26.

[0133] With particular reference to Figure 1, package filling apparatus 17 may be configured to produce packages 2 and to fill packages 2 with the pourable product.

[0134] In more detail, package filling apparatus 17 may be configured to produce packages 2 by forming a tube 50 from web 3, longitudinally sealing tube 50, filling tube 50 with the pourable product and to transversally seal and cut tube 50.

[0135] In use, packaging plant 1 produces packages 2 filled with the pourable product.

[0136] Operation of packaging plant 1 comprises at least the steps of:

- forming and filling packages 2 with the pourable product, in particular executed by of package filling apparatus 17; and
- securing caps 12 on collars 8, in particular executed by capping machine 18.

[0137] Operation of packaging plant 1 also comprises a step of inspecting, during which the orientation of each cap 12 with respect to the respective main body 4 is inspected.

[0138] Even more particular, during the step of forming and filling, tube 50 is formed from advancing web 3, is longitudinally sealed, filled with the pourable product and transversally sealed and cut.

[0139] According to some preferred embodiments, operation of packaging plant 1 may also comprise a step of feeding, during which packages 2 are fed, in particular from package filling apparatus 7, to capping machine 18.

[0140] In more detail, during the step of securing, the following sub-steps are executed:

- advancing main bodies 4 along the advancement path; and
- applying caps 12 onto main bodies 4;

[0141] In more detail, during the sub-step of applying, caps 12 are applied onto the respective collars 8, in particular by means of the cap application device, so as to apply caps 12 onto main bodies 4.

[0142] Additionally, during the step of securing, also the sub-step(s) of:

- securing caps 12 on collars 8 by means of a cap securing device; and/or
- sealing the connection elements to caps 12;

is/are executed.

[0143] Additionally, after the application of caps 12, caps 12 are inspected according to the following method. The method is cyclically executed for each cap 12.

[0144] The method comprises the steps of:

- imaging, during which at least one, more specifically exactly one, image 21 per package 2 of the respective inspection portion 22 of the respective package 2 is acquired; and
- analyzing, during which each image 21 is analyzed so as to determine the orientation of each cap 12 with respect to the respective reference line 25 of the respective main body 4, more specifically of the respective second wall 7.

[0145] More specifically, the step of imaging may be executed by the imaging device and the step of analyzing may be executed by the analyzing unit.

[0146] By analyzing the respective orientation of each cap 12 with respect to the respective reference line 25 it is possible to understand the respective orientation of each

cap 12 with respect to the respective main body 4, more specifically the respective second wall 7.

[0147] In more detail, during the step of analyzing from each image 21 at least one first reference point 26 of the at least one auxiliary portion; i.e. of the respective opening lip 14 when reverting to the embodiment of Figures 2 to 3C, is determined and a linear line 27 between the determined first reference point 26 and the respective second reference point 28 of the respective cap 12 are obtained.

[0148] Additionally, during the step of analyzing also the respective orientation angle between the respective linear line 27 with respect to the corresponding reference line 25 is obtained. It is the respective orientation angle which describes the orientation of the respective cap 12 with respect to the respective main body 4, more specifically with respect to the respective second wall 7.

[0149] According to some non-limiting embodiments, during the step of analyzing, from each image 21 the respective reference line 25 is determined from the respective transversal seal 8 of the respective main body 4, more specifically of the respective second wall 7. Thereby, the respective reference line 25 is parallel to and/or extends along the respective transversal seal 8.

[0150] In further detail, during the step of analyzing, each first reference point 26 may be calculated from and/or based on the respective set 23 of pixels.

[0151] In even further detail, during the step of analyzing, at least the respective circle 30 having the respective diameter d2 larger than the respective diameter d1 is fitted, more specifically based on the respective first set 23 of pixels. Moreover, during the step of analyzing, each first reference point 26 is calculated from the respective arc-shaped profile portion 31.

[0152] More specifically, during the step of analyzing, each first reference point 26 may be calculated as the respective profile center of the respective arc-shaped profile portion 31.

[0153] According to the embodiment of Figures 2 to 3C, during the step of analyzing the respective center 19 of the respective principal wall 13 is taken as the respective second reference point 28.

[0154] With reference to Figures 4 and 5, number 12' indicates an alternative cap differing from cap 12.

[0155] Cap 12' differs from cap 12 in comprising two auxiliary portions 14', each auxiliary portion protruding from the respective principal wall 13 and being arranged opposite from one another.

[0156] Additionally, cap 12' differs from cap 12 in that control between the respective open position and the respective closed position occurs by means of a rotation about the respective center axis. In particular, cap 12' is a screw cap, detachably connected to collar 11.

[0157] In particular, auxiliary portions 14' are configured to facilitate gripping of cap 12' and the actuation of the rotary movement about the respective center axis.

[0158] Inspection apparatus 20 may be configured determine orientation of caps 12' with respect to the respective main body 4, more specifically the respective second wall 7, in a manner similar to the one described with respect to cap 12. I.e. inspection apparatus 20 may operate such that one auxiliary portion 14' is used to determine the respective first reference point 26 and to consider the respective center 19 as the second reference point 28.

[0159] Alternatively, the presence of the two auxiliary portions 14' allows to determine the respective first reference point 26 from one auxiliary portion 14' and the respective second reference point 28 from the other auxiliary portion 14'.

[0160] Accordingly, the analyzing unit may be configured to determine from each image 21 the respective first reference point 26 from one of the respective auxiliary portions 14' and to determine the respective second reference point 28 from the other auxiliary portion 14'.

[0161] More specifically, the analyzing unit may be configured to fit the respective circle 30, in particular based on the respective first set 23 of pixels. The respective circle 30 comprises two arc-shaped profile portions 31, each one extending along one respective auxiliary portion 14'.

[0162] Even more specifically, the analyzing unit may be configured to consider the respective profile centers of the arc-shaped profile portions 31 for determining the respective first center point 26 and the respective second center point 28.

[0163] According to some possible embodiments, the analyzing unit may be configured to determine from each image 21 a plurality of pairs of one respective first reference point 26 and one respective second reference point 28 and to determine from each pair of one respective first reference point 26 and one respective second reference point 28 one respective linear line 27.

[0164] Moreover, the analyzing unit may also be configured to calculate respective orientation angles between each one of the plurality of linear lines 27 and the respective reference line 25.

[0165] Finally, the analyzing unit may also be configured to average the plurality of orientation angles for determining the orientation of the cap 12' with respect to the main body 4.

[0166] In further detail, each pair of one respective first reference point 26 and one respective second reference point 28 may be obtained by the analyzing unit fitting a respective circle 30 having the respective diameter d2. By the analyzing unit being configured to fit more than one circle 30 having differing diameters d2, one also obtains differing first reference points 26 and differing second reference points 28.

[0167] The method of inspecting caps 12' applied to main bodies 4 can be based on the above-described method. Alternatively, it is possible to modify the method such to rely on the presence of two auxiliary portions 14', one auxiliary portion 14' allowing to determine the respective first reference point 26 and the other auxiliary portion 14' allowing to determine the respective second

reference point 28.

[0168] In more detail, this method differs from the above-described one in that during the step of analyzing from each image 21, the respective first reference point 26 is determined from one of the auxiliary portions 14' and the second reference point 28 is determined from the other auxiliary portion 14'. This then allows to determine the respective linear line 27.

[0169] More specifically, each first reference point 26 and the respective second reference point 28 are obtained by fitting the respective circle 30 having the respective diameter d2, in particular based on the respective first set 23 of pixels, and to determine the respective first reference point 26 and the respective second reference point 28 from the respective arc-shaped profile portion 31.

[0170] Even more specifically, during the step of analyzing the respective profile centers of the respective arc-shaped profile portions 31 give rise to the respective first reference point 26 and the respective second reference point 28.

[0171] According to some possible embodiments, during the step of analyzing, from each image 21 a plurality of pairs of one respective first reference point 26 and one respective second reference point 28 are determined.

[0172] More specifically, the pairs of one respective first reference point 26 and the respective second reference point 28 may be obtained by fitting respective circles 30 having respective differing diameters d2 and to analyze the respective arc-shaped profile portions 31 for obtaining the respective first reference points 26 and the respective second reference points 28.

[0173] Moreover, during the step of analyzing from each pair of one respective first reference point 26 and one respective second reference point 28 one respective linear line 27 is determined, the respective orientation angles between the plurality of linear lines 27 and the respective reference line 25 are calculated and the plurality of orientation angles are averaged for determining the orientation of the respective cap 12' with respect to the main body 4, more specifically the respective second wall 7.

[0174] When relying on more than one linear line 27 it is possible to further improve the preciseness of the method.

[0175] The advantages of inspection apparatus 20 and the method according to the present invention will be clear from the foregoing description.

[0176] In particular, inspection apparatus 20 and/or the method of inspection allow to determine with high precision the orientation of caps 12 and 12' with respect to main body 4. This again, allows to guarantee that packages 2 delivered to an end consumer present the desired functionality; i.e. caps 12 and 12' can be correctly moved between the respective closed position to the respective open configuration, in particular so that during a first time movement form the closed position to the open position, the separation membrane detaches.

[0177] Clearly, changes may be made to inspection apparatus 20 and/or capping machine 18 and/or packaging plant 1 and/or the method as described herein without, however, departing from the scope of protection as defined in the accompanying claims.

Claims

1. Inspection apparatus (20) for inspecting caps (12; 12') applied to main bodies (4) of respective packages (2); wherein each cap (12; 12') comprises a principal wall (13) and at least one auxiliary portion (14; 14') protruding from the principal wall (13);

   wherein the inspection apparatus (20) comprises:

   - an imaging device configured to acquire at least one image (21) per package (2) of an inspection portion (22) of the package (2), wherein the inspection portion (22) has: at least a portion of a main body (4) of the package (2), and the cap (12; 12'); and
   - an analyzing unit is configured to analyze each image (21) and to determine an orientation of the cap (12; 12') with respect to a reference line (25) of the respective main body (4);

   wherein the analyzing unit is configured to determine from each image (21) at least one first reference point (26) of the at least one auxiliary portion (14; 14') and to obtain a linear line (27) between the determined first reference point (26) and a second reference point (28) of the cap (12; 12');
   wherein the analyzing unit is also configured to determine an orientation angle of the linear line (27) with respect to the reference line (25), the orientation angle describing the orientation of the cap (12; 12') with respect to the main body (4).

2. Inspection apparatus according to claim 1, wherein the analyzing unit is configured to determine from each image (21) the respective reference line (25) from a transversal seal (8) of the main body (4), the reference line (25) being parallel to and/or extending along the transversal seal (8).

3. Inspection apparatus according to any one of the preceding claims, wherein each image (21) comprises a set (23) of pixels representing and/or corresponding to the cap (12; 12');
   the analyzing unit is configured to calculate the first reference point (26) from and/or based on the set (23) of pixels.

4. Inspection apparatus according to any one of the preceding claims, wherein the principal wall (13) has a circular shape;

wherein the analyzing unit is configured to fit at least one circle (30) having a respective diameter (d2) larger than a respective diameter (d1) of the principal wall (13), wherein the circle (30) has an arc-shaped profile portion (31) extending within the auxiliary portion (14; 14');
wherein the analyzing unit is configured to calculate the first reference point (26) from the arc-shaped profile portion (31).

5. Inspection apparatus according to any one of the preceding claims, wherein the analyzing unit is configured to define a center (19) of the principal wall (13) as the second reference point (28).

6. Inspection apparatus according to any one of claims 1 to 4, wherein the cap (12') comprises two auxiliary portions (14') protruding from the principal wall (13) and being arranged opposite from one another;
wherein the analyzing unit is configured to determine from each image (21) the first reference point (26) of from one of the auxiliary portions (14') and to determine the second reference point (28) from the other auxiliary portion (14') .

7. Inspection apparatus according to claim 6, wherein the analyzing unit is configured to determine from each image (21) a plurality of pairs of one respective first reference point (26) and one respective second reference point (28);

wherein the analyzing unit is configured to determine from each pair of one respective first reference point (26) and one respective second reference point (28) one respective linear line (27);
wherein the analyzing unit is also configured to calculate respective orientation angles between the plurality of linear lines (27) and the reference line (25) and the analyzing unit is configured to average the plurality of orientation angles for determining the orientation of the cap (12; 12') with respect to the main body (4).

8. Inspection apparatus according to any one of the preceding claims, wherein the analyzing unit is configured to determine a correctly applied cap (12, 12') if the respective orientation angle lies within a pre-determined range and/or to determine an incorrectly applied cap (12, 12') if the respective orientation angle lies outside of a pre-determined range.

9. Inspection apparatus according to any one of the preceding claims, wherein the imaging device comprises a 3D camera.

10. Capping machine (18) for applying caps (10) onto main bodies (4) of packages (2) comprising:

- a cap application apparatus configured to apply caps (12; 12') onto the main bodies (4) of the packages (2); and
- an inspection apparatus (20) according to any one of the preceding claims configured to inspect the orientation of each respective cap (12; 12') with respect to the respective main body (4).

11. Packaging plant (1) for producing packages (2) having each a main body (4) and a cap (12; 12') applied onto the main body (4) and being filled with a pourable product comprising:

- a package filling apparatus (17) for forming and filling the main bodies (4) with the pourable product; and
- at least one capping machine (18) according to claim 10.

12. Method of inspecting caps (12; 12') applied to respective main bodies (4) of respective packages (2); wherein each cap (12; 12') comprises a principal wall (13) and at least one auxiliary portion (14; 14') protruding from the principal wall (13);

wherein the method comprises the steps of:

- imaging, during which at least one image (21) per package (2) of an inspection portion (22) of the package (2) is acquired, the inspection portion (22) having at least a portion of a main body (4) of the package (2) and at least the cap (12; 12'); and
- analyzing, during which each image (21) is analyzed so as to determine an orientation of the cap (12; 12') with respect to a reference line (25) of the respective main body (4) ;

wherein during the step of analyzing from each image (21) at least one first reference point (26) of the at least one auxiliary portion (14; 14') is determined and a linear line (27) between the determined first reference point (26) and a second reference point (28) of the cap (12; 12') is obtained;
wherein during the step of analyzing unit also an orientation angle of the linear line (27) with respect to the reference line (25) is obtained, the orientation angle describing the orientation of the cap (12; 12') with respect to the main body (4).

13. Method according to claim 12, wherein during the step of analyzing from each image (21) the respective reference line (25) is determined from a transversal seal (8) of the main body (4), the reference line (25) being parallel to and/or extending along the transversal seal (8).

14. Method according to claim 12 or 13, wherein each image (21) comprises a set (23) of pixels representing and/or corresponding to the cap (12; 12'); wherein during the step of analyzing, the first reference point (26) is calculated from and/or based on the set (23) of pixels.

15. Method according to any one of claims 12 to 14, wherein the principal wall (13) has a circular shape;

wherein during the step of analyzing at least one circle (30) having a respective diameter (d2) larger than a respective diameter (d1) of the principal wall (13) is fitted, the circle (30) having an arc-shaped profile portion (31) extending within the auxiliary portion (14; 14');
wherein during the step of analyzing, the first reference point (26) is calculated from the arc-shaped profile portion (31).

16. Method of applying caps (12; 12') onto main bodies (4) of packages (2) comprising the steps of:

- advancing main bodies (4) along an advancement path;
- applying caps (12; 12') onto the main bodies (4); and
- inspecting the caps (12; 12') by executing a method according to any one of claims 12 to 15.

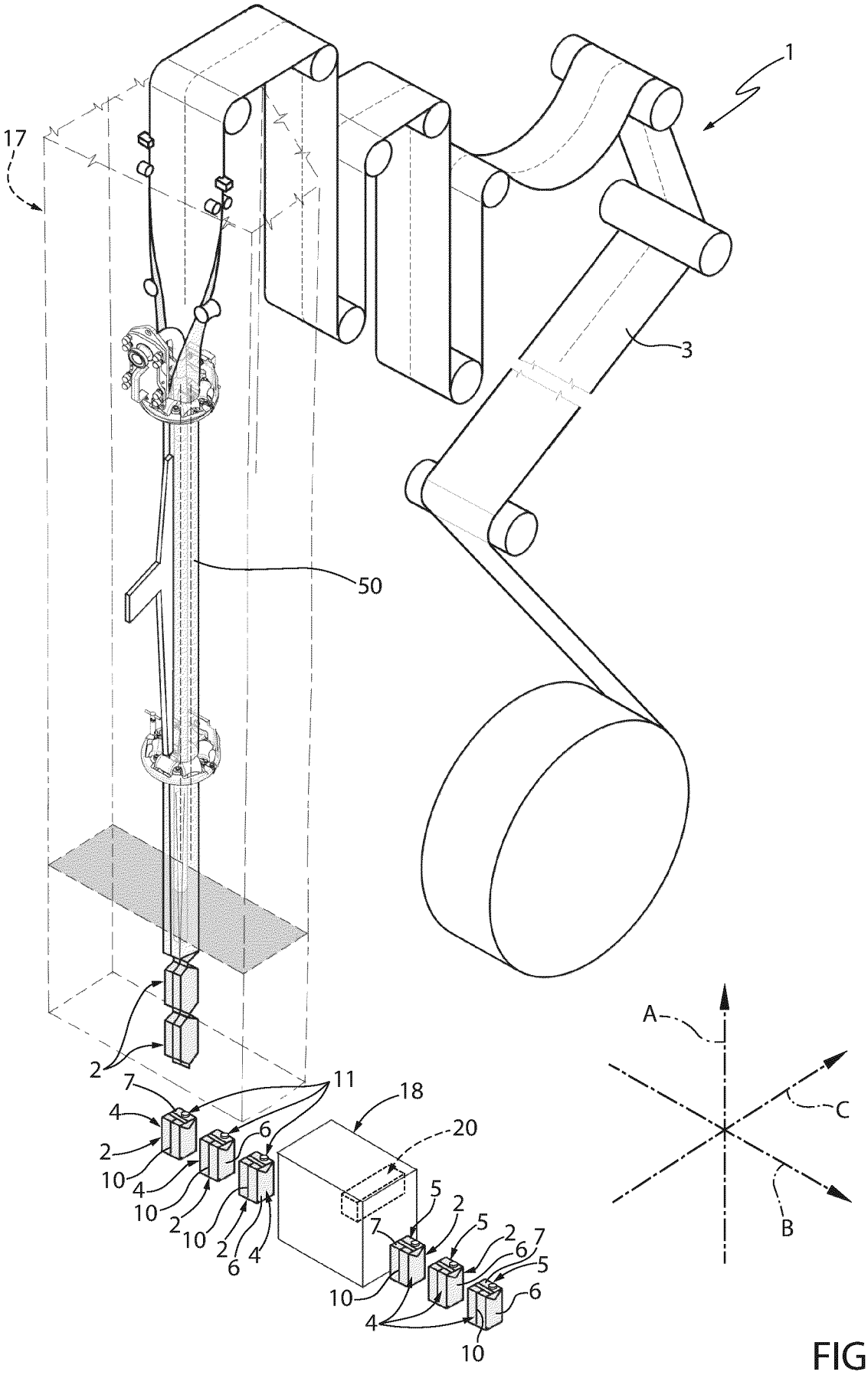

FIG.1

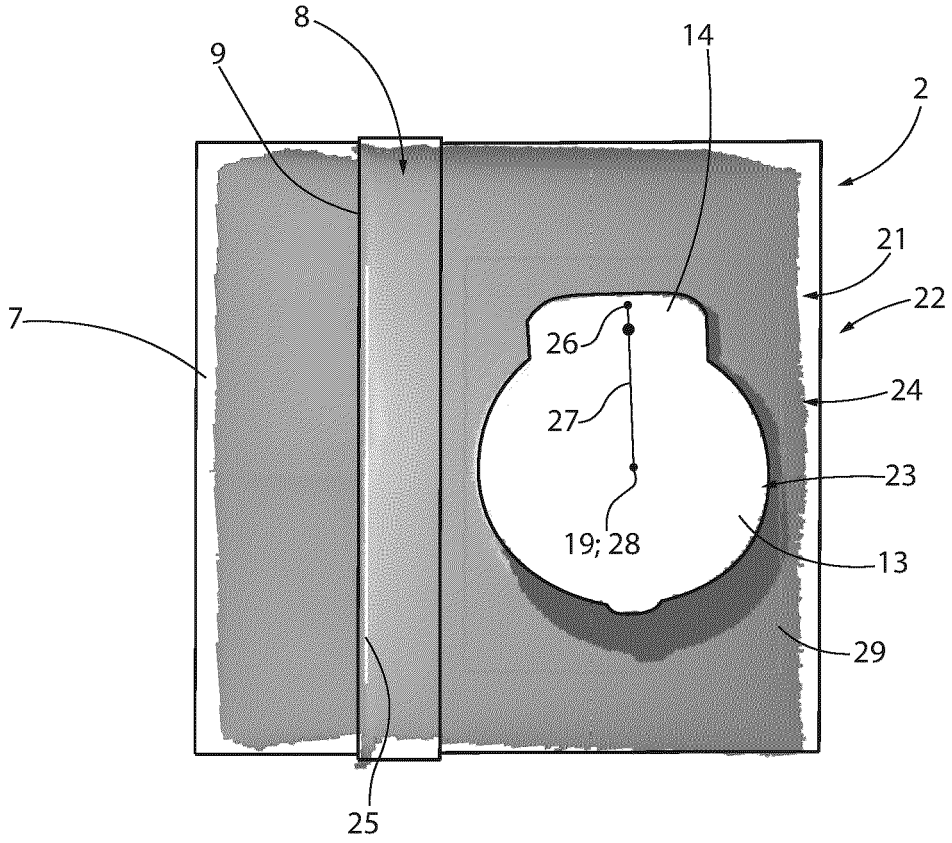

FIG.2

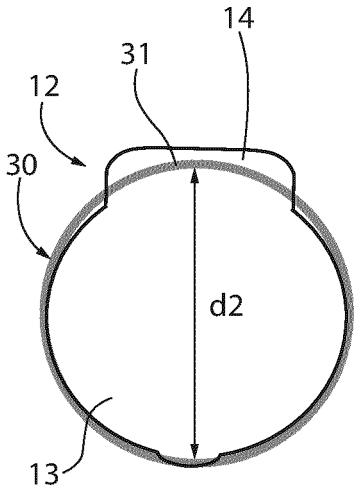

FIG.3A

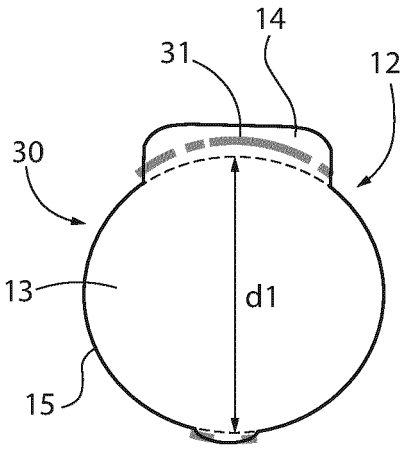

FIG.3B

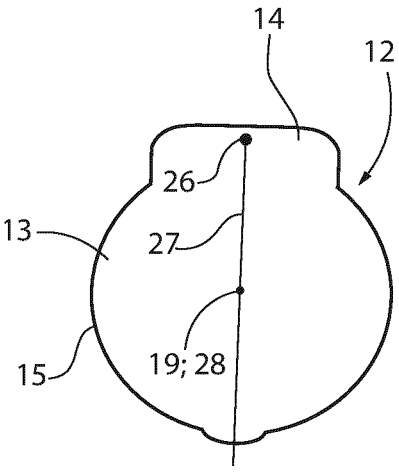

FIG.3C

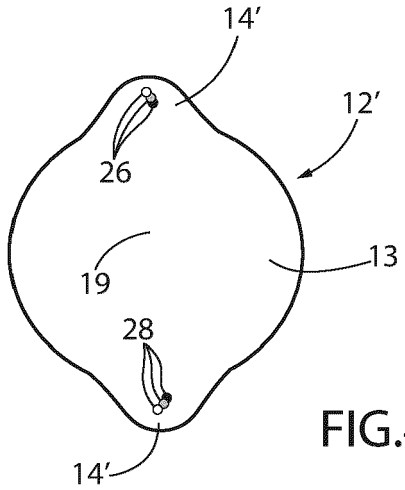

FIG.4

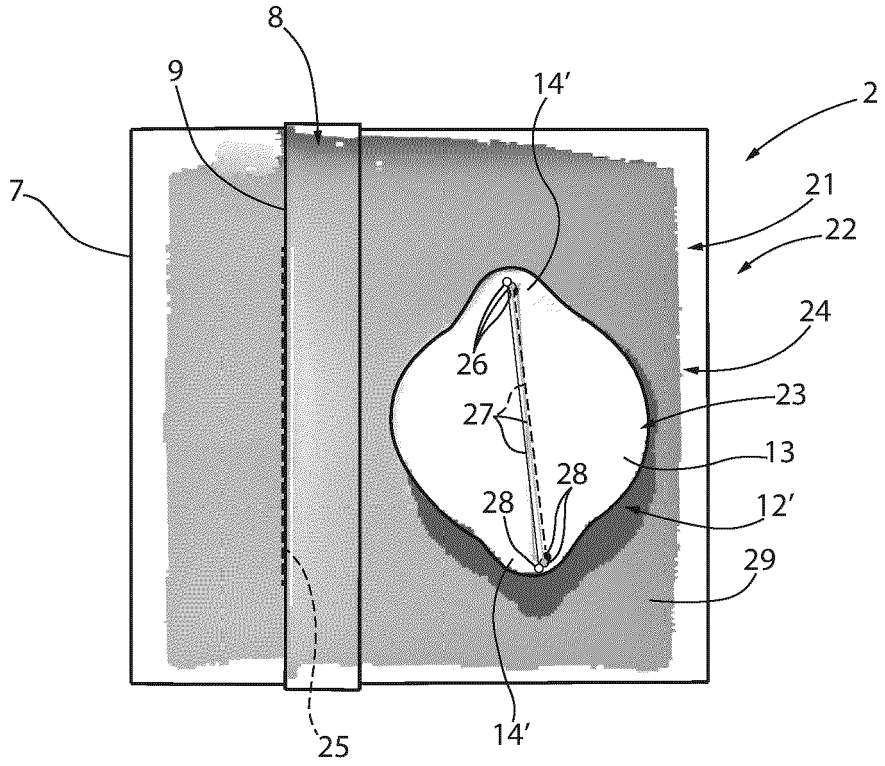

FIG.5

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EUROPEAN SEARCH REPORT

Application Number
EP 24 19 2277

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2022/248145 A1 (TETRA LAVAL HOLDINGS & FINANCE [CH]) 1 December 2022 (2022-12-01) * page 8, line 11 - line 19 * * page 12, line 18 - line 23 * * figures 1, 3 *	1-16	INV. B67B3/26 B65B7/28
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TECHNICAL FIELDS SEARCHED (IPC)

B67B
B65B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 January 2025	Luepke, Erik

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07-01-2025

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