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(54) A CAPSULE, A SYSTEM FOR PREPARING A POTABLE BEVERAGE FROM SUCH A CAPSULE AND USE OF SUCH A CAPSULE IN A BEVERAGE PREPARATION DEVICE

KAPSEL, SYSTEM ZUR VORBEREITUNG VON GETRÄNKEN UND VERWENDUNG DER KAPSELN

CAPSULE, SYSTEM POUR LA PREPARATION DES BOISSONS ET L'USAGE DES CAPSULES

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Description

[0001] The invention relates to a capsule according to the introductory portion of claim 1.

[0002] Such a capsule, such a system and such a use are known from EP-B-1 700 548, and WO2014/184653 A1 which disclose a capsule provided with a sealing structure having the shape of a step, i.e. a sudden increase of the diameter of the side wall of the capsule, and the enclosing member of this known system has a sealing surface acting on the sealing structure to provide deflection of the sealing structure, the sealing surface being inclined so that the deflection of the sealing structure is an inwards and downwards deformation of the step. Furthermore in the known system the enclosing member comprises a capsule holder and a manually operated or an automatic mechanism for relative displacement of the enclosing member and the capsule holder. The manually operated or automatic mechanism applies a force on the sealing structure of the capsule when the enclosing member closes on the capsule holder. This force should ensure the fluid tight seal between the enclosing member and the capsule. Because the manually operated or automatic mechanism is arranged to be moved relative to the base, the sealing capabilities of the system can depend on the pressure of the fluid injected by the fluid injection means. If the pressure of the fluid increases, the force between the sealing structure of the capsule and the free end of the enclosing member increases too and thereby the force between the sealing structure of the capsule and the free end of the enclosing member increases also. Such a system is described further on. The sealing structure of the capsule must be arranged such that upon reaching the maximum fluid pressure in the enclosing member the sealing structure should still provide a fluid sealing contact between the enclosing member and the capsule. However, the sealing structure must also be arranged such that prior to, or at the start of, brewing when the pressure of the fluid in the enclosing member outside the capsule is relatively low, the sealing structure also provides a sealing contact between the enclosing member and the capsule. If at the start of brewing, there would not exist a sealing contact between the capsule and the enclosing member, leakage will occur. However, if leakage occurs there is a real chance that the pressure in the enclosing member and outside the capsule will not sufficiently increase for increasing the force on the sealing structure by means of the free end of the enclosing member if the manually operated or automatic mechanism moves the enclosing member towards the capsule holder. Only if there is a sufficient initial sealing, the pressure in the enclosing member will increase whereby also the force of the free end of the enclosing member acting on the sealing structure of the capsule will increase for providing a sufficient sealing contact at also the increased fluid pressure. Moreover, this increased fluid pressure outside the capsule also provides an increased fluid pressure inside the capsule which is essential if the capsule is provided with a cover which is arranged to tear open on relief members of the capsule holder (also called an extraction plate) of the beverage preparation device under the influence of fluid pressure in the capsule.

[0003] It follows from the above that the sealing structure is a member which is very critical in design. It should be able to provide a sealing contact between the enclosing member and the capsule at a relatively low fluid pressure if only a relatively small force is applied on the sealing structure by means of the free end of the enclosing member but it should also provide a sealing contact at a much higher fluid pressure in the enclosing member outside the capsule if a higher force is applied by means of the free end of the enclosing member to the sealing structure of the capsule. In particular when the annular end surface of the enclosing member is provided with radially extending open grooves which act as air inlet passage once the force between the enclosing member and the capsule holder is released so that it is easier for a user to take out the capsule, the sealing structure must also be able to 'close' the radially extending open grooves to provide an effective seal.

[0004] From WO2012/120459, a capsule is known in which the sealing structure includes a deformable portion of the outwardly projecting flange of the capsule body. However, for ensuring that the sealing ring portion provides a sealing contact against the annular end surface of the enclosing member, as it is deformed between that annular surface and the closing member, the annular end surface of the enclosing member has deforming means in the form of a shallow, rounded groove extending in circumferential sense of the annular surface. In operation, the shallow, rounded groove ensures that an upstanding rib of the deformable portion folds over inwardly. Accordingly, reliable functioning of such capsules will be ensured for use in particular beverage preparation devices only.

[0005] It is an object of the invention to provide a capsule that reliably seals against the annular end surface of an enclosing member of a beverage preparation device if the capsule is positioned in the enclosing member of the beverage preparation device and the enclosing member is closed by means of a closing member of the beverage preparation device, such as an extraction plate of the beverage preparation device, a portion of the outwardly extending flange of the capsule and the sealing structure of the capsule being clamped between the annular end surface of the enclosing member and the closing member of the beverage preparation device, even in case of an enclosing member of which the annular end surface is provided with radially extending open grooves and which can still be manufacture at low costs and is environmentally friendly and easily recyclable after the capsule has been disposed of after use. In many of the known capsules, the sealing member is made from an elastic material such as rubber elastic material, more specific such as a silicon material which after use, should

be separated from the aluminum base and cover for recycling purposes.

[0006] This object is achieved by providing a capsule according to claim 1.

[0007] Because the sealing structure includes a deformable sealing ring portion of the flange, the sealing ring portion projecting axially from base portions of the flange on a side of the base portions opposite of the cover, the sealing structure is integrated in the flange of the capsule, so the capsule can be manufactured quickly at low costs and the aluminum capsule body can be recycled easily. In the present context, the meaning of 'aluminum' is understood to also include aluminum alloy.

[0008] Because a top of the bridge portion axially most remote from the base portions of the flange is flat or has a center plane curved with a radius of curvature larger than two times a wall thickness of said top of the bridge portion, the bridge portion is easily deformable locally at low clamping pressure to accommodate to the shape of the annular end surface of the enclosing member when clamped between the annular end surface of the enclosing member and the closing member. Even in case of an enclosing member of which the annular end surface is provided with radially extending open grooves, the sealing structure can accommodate to the succession of projections and recesses in circumferential sense formed by the annular end surface of the enclosing member and effectively seal, also against the recessed surface portions of the annular end surface already during an early stage of the closing of the enclosing member when the clamping pressure at which the enclosing member and the closing member are pressed against each other is relatively low.

[0009] It is noted that for the sealing between the annular end surface of the enclosing member and the sealing ring portion of the flange to be effective for ensuring that the pressure drop over the substance in the capsule is sufficient for the desired beverage preparation process, it does not have to be hermetically fluid tight under all circumstances. At a liquid leakage of up to 4% and preferably not beyond 2,5 % of the liquid volume pumped through the capsule, the seal is still effective for allowing the beverage preparation apparatus to generate the desired pressure drop over the substance. Accordingly, a sealing allowing such a leakage constitutes an effective sealing.

[0010] The invention can also be embodied in a system according to claim 14, an use according to claim 18 and a method of manufacturing a capsule body according to claim 19. In operation of such a system and in such a use, the bridge portion easily deforms locally, thereby accommodating to the shape of the annular end surface of the enclosing member when it is clamped between the annular end surface of the enclosing member and the closing member. More in particular, the sealing structure accommodates to the succession of projections and recesses in circumferential sense formed by the annular end surface of the enclosing member and effectively seals, also against the recessed surface portions of the annular end surface already during an early stage of the closing of the enclosing member, when the clamping pressure at which the enclosing member and the closing member are pressed against each other is relatively low.

[0011] A good conformability to the shape of the annular end surface and accordingly a particularly effective and reliable sealing already at low sealing pressure can be achieved if at least a portion of the top of the bridge portion has a reduced wall thickness smaller than a wall thickness of the inner and outer wall portions.

[0012] If the capsule body has a coating to at least one side, leaving out the coating in at least the portion of the top of the bridge portion having a reduced wall thickness reduces the risk of the coating being damaged or becoming unstuck during relatively large deformations occurring when the wall thickness is reduced during manufacturing. The coating may also be removed while reducing the wall thickness during manufacturing, for instance if reducing the wall thickness involves removing wall material.

[0013] A further enhanced sealing effect can be achieved if the uncoated portion of the bridge portion is on a side of the flange opposite of the cover and has a textured surface. A texture in the surface can further improve the conformability during early stages of clamping, when the sealing pressure is still low, because clamping force is transferred via raised portions of the texture only, so that at the raised portions a higher contact pressure is exerted than would be exerted over a full smooth contact surface.

[0014] A particularly improved sealing effect can be achieved if the textured surface includes ridges and valleys extending in circumferential sense of the flange, because early conformation to the shape of the annular end surface is then achieved in generally annular areas or ring sectors extending mainly in circumferential sense.

[0015] The invention can also be embodied in a method according to claim 52 for manufacturing such a capsule. The coating is efficiently removed from the portion of the flange of which the wall thickness is to be reduced prior to or during reducing the wall thickness.

[0016] A particularly efficient manufacturing of the reduced wall thickness can be achieved if the coating is removed from the portion of the flange of which the wall thickness is to be reduced during a material removal step for removing wall material for reducing the wall thickness.

[0017] However, a coating on the top portion of the bridge portion, either the same coating as on the remainder of the outer surface of the capsule body or a coating different from the coating on the remainder of the outer surface of the capsule body, can also improve sealing, for instance by reducing friction between the annular end surface of the enclosing member and a surface portion of the sealing ring portion in contact with the annular end surface, which facilitates accommodation of the sealing ring portion in contact with the annular end surface to the shape of the annular end surface.

[0018] If one of the inner and outer wall portions is oriented at a different angle to the base portions of the flange than the other one of the inner and outer wall portions, accurate and reliable deformation of the sealing structure to a predetermined shape during sealing can be achieved. In particular the occurrence of transitions between circumferential portions deforming to different end shapes, entailing an increased risk of leakage, is thereby counteracted.

[0019] This effect can be achieved particularly effectively if one of the inner and outer wall portions extends at an oblique angle, preferably of 20-60°, and more preferably 30-50°, relative to a plane of the associated contiguous base portion of the flange and the other one of the inner and outer wall portions extends from the associated contiguous base portion of the flange at a steeper or opposite angle, preferably 60-160°, and more preferably 70-150° relative to a plane of the associated contiguous base portion of the flange.

[0020] For a smooth, accurate and reliable deformation to a predetermined shape, it is advantageous if, in cross-sectional view, at least a portion of at least one of the inner and outer wall portions has a curved center plane, in particular if the curved portion of the at least one of the inner and outer wall portions is contiguous to the curvature of the top of said bridge portion and if, in cross-sectional view, the deformable portion is Ω shaped. Another advantage of an Ω shape is that only a small gap is left between inner and outer base portions of the flange so that a large surface area for adherence of the cover to the flange is left.

[0021] For obtaining a high counter pressure during a final stage of deformation of the sealing structure, a support member may be provided between the inner and outer wall portions.

[0022] A particularly easy accommodation to the shape of the annular end surface may be achieved if, the top of the bridge portion is positioned for being contacted first by the annular end portion, when the sealing ring portion is clamped between the annular end surface and the closing member of a compatible beverage preparation device.

[0023] The top of the bridge portion forms a rounded or flat crest extending circumferentially around the center line of the capsule. By providing that the crest formed by the top of the bridge portion has a diameter of 29-33 mm, more preferably 30.0-31.4 mm and most preferably 30.3-31.0 mm, the top of the bridge portion is located centrally relative to the annular end surface for first contacting a central portion of said annular end surface when the sealing ring portion is clamped between the annular end surface and said closing member of widely used and commercially available beverage preparation devices such as the Citiz, Lattisima, U, Maestria, Pixie, Inissia and Essenza.

[0024] The invention is in particular advantageous when in an embodiment of a capsule the capsule is filled with 5-20 grams, preferably 5-10 grams, more preferably 5-7 grams of an extractable product, such as roasted and ground coffee.

[0025] In an embodiment of a capsule according to the invention which is in particular easy to manufacture the outer diameter of the outwardly extending flange of the capsule is larger than the diameter of the bottom of the capsule. Preferably, the outer diameter of the outwardly extending flange is approximately 37.1 mm and the diameter of the bottom of the capsule is about 23.3 mm.

[0026] The invention is in particular advantageous when in an embodiment of a capsule the thickness of the aluminum capsule body is 20 to 200 micrometer, preferably 100 micrometer.

[0027] The invention is in particular advantageous when in an embodiment of a capsule the thickness of the aluminum cover is 15 to 65 micrometer, preferably 30-45 micrometer and more preferably 39 micrometer.

[0028] In an embodiment of a capsule according to the invention the thickness of the aluminum cover is smaller than the thickness of the aluminum capsule body.

[0029] In a further embodiment of a capsule according to the invention the aluminum cover is arranged to tear open on a closing member of the beverage preparation device, such as an extraction plate of the beverage preparation device under the influence of fluid pressure in the capsule.

[0030] In an embodiment of a capsule according to the invention which is in particular easy to manufacture the side wall of the aluminum capsule body has a free end opposite the bottom, the outwardly extending flange extending from said free end of the side wall in a direction at least substantially transverse to the central capsule body axis. Preferably, the outwardly extending flange comprises a curled outer edge, which is beneficial in obtaining for a satisfactory sealing with the annular end surface provided with radially extending open grooves. The radius about the central capsule body axis of an inner edge of the curled outer edge of the outwardly extending flange is preferably at least 32 mm, so that clearance from the annular end surface of the enclosure member is ensured. It is then preferred that the sealing structure is positioned between the free end of the side wall of the aluminum capsule body and an inner edge of the curled outer edge of the outwardly extending flange to obtain a still further satisfactory sealing.

[0031] To ensure that the curled outer edge does not interfere with operation of a wide variety of commercially available and future beverage preparation apparatuses, the outwardly extending flange has a largest radial cross-sectional dimension of about 1.2 millimeter.

[0032] The invention is in particular beneficial for capsules of which the inner diameter of the free end of the side wall of the aluminum capsule body is about 29.5 mm. The distance between the free end of the side wall of the aluminum capsule body and an outermost edge of the outwardly extending flange can be about 3.8 millimeter. The preferred height of the aluminum capsule body is about 28.4 mm.

[0033] In an embodiment of a capsule according to the invention which after use is easier for a user to take out of a beverage preparation device the aluminum capsule body is truncated, wherein preferably the side wall of the aluminum capsule body encloses an angle with a line transverse to the central capsule body axis of about 97.5°.

[0034] In an advantageous embodiment of a capsule according to the invention the bottom of the aluminum capsule body has a largest inner diameter of about 23.3 mm. It is preferred that the bottom of the aluminum capsule body is truncated, preferably having a bottom height of about 4.0 mm and that the bottom further has a generally flat central portion opposite the cover having a diameter of about 8.3 mm.

[0035] In practically all cases a satisfactory seal can be obtained in an embodiment of a capsule according to the invention in which the height of the sealing structure is at least about 0.1 mm, more preferably at least 0.2 mm and most preferably at least 0.8 mm and at most 3 mm, more preferably at most 2 mm and most preferably at most 1.2 mm.

[0036] Regarding the preferred embodiments of the system as mentioned in the dependent claims which relate to the same features as the features of the dependent claims of the capsule reference is made to the above.

[0037] The invention is particularly suitable in a system according to the invention wherein, in use, the maximum fluid pressure in the enclosing member of the beverage preparation device is in the range of 6-20 bar, preferably between 12 and 18 bar. Even at such high pressures a satisfactory seal between capsule and beverage preparation device can be obtained.

[0038] Preferably the system is arranged such that, in use, during brewing, a free end of the enclosing member of the beverage preparation device exerts a force F2 on the sealing structure of the capsule to provide a sealing contact between the outwardly extending flange of the capsule and the enclosing member of the beverage preparation device, wherein F is in the range of 500-1500 N preferably in the range of 750-1250 N when the fluid pressure P2 in the enclosing member of the beverage preparation device outside the capsule is in the range of 6-20 bar, preferably between 12 and 18 bar. In particular the system is arranged such that, in use, prior to or at the start of brewing, a free end of the enclosing member of the beverage preparation device exerts a force F1 on the sealing structure of the capsule to provide a sealing contact between the outwardly extending flange of the capsule and the enclosing member of the beverage preparation device, wherein F1 is in the range of 30-150 N preferably 40-150 N, more preferably 50-100 N, when the fluid pressure P1 in the enclosing member of the beverage preparation device outside the capsule is in the range of 0.1-4 bar, preferably 0.1-1 bar.

[0039] In an embodiment of a system according to the invention wherein the plurality of radially extending open grooves are uniformly spaced relative to each other in tangential direction of the annular end surface of the annular element of the beverage preparation device so that it is easier for a user to take out the capsule while a satisfactory seal between capsule and beverage preparation device can still be provided.

[0040] In an advantageous embodiment of a system according to the invention the longest tangential width of each groove (top to top, i.e. equal to the groove to groove pitch) is 0.9 - 1.1 mm, preferably 0.95 to 1.05 mm, more preferably 0.98 to 1.02 mm, wherein a maximal height of each groove in an axial direction of the enclosing member of the beverage preparation device is 0.01 - 0.09 mm, preferably 0.03 to 0.07 mm, more preferably 0.045 to 0.055 mm, most preferred 0.05 mm and wherein the number of grooves is 90 to 110, preferably 96. The radial width of the annular end surface at the location of the grooves may for instance be 0.05- 0.9 mm, preferably 0.2- 0.7 mm and more preferably 0.3 - 0.55 mm.

[0041] The invention is in particular suitable when applied to an embodiment of system according to the invention in which during use when the closing member of the beverage preparation device closes the enclosing member of the beverage preparation device the enclosing member of the beverage preparation device can move relative to the closing member of the beverage preparation device under the effect of the pressure of the fluid in the enclosing member of the beverage preparation device towards the closing member of the beverage preparation device for applying the maximum force between the flange of the capsule and the free end of the enclosing member of the beverage preparation device.

[0042] Further aspects, effects and details of the invention will now be further described with reference to, non-limiting, examples shown in the drawing, in which:

Fig. 1 shows a schematic representation of an embodiment of a system according to the invention;
Fig. 2 in a perspective view shows an embodiment of a beverage preparation device of a system according to the invention showing the annular end surface of the enclosing member of the beverage preparation device with the plurality of radially extending open grooves;
Fig. 3A in cross section shows an embodiment of a capsule according to the invention before use;
Fig. 3B shows an enlarged detail of a the capsule of Fig. 3A showing the outwardly extending flange and the sealing structure;
Fig. 3C shows an enlarged detail of the outwardly extending flange of the capsule in Figures 3A and 3B after use;
Figs. 4A to 4H show several embodiments of a sealing structure at the outwardly extending flange of a capsule according to the invention.

[0043] Fig. 1 shows a schematic representation, in cross sectional view, of an embodiment of a system 1 for preparing a potable beverage from a capsule using a

fluid supplied under pressure into the capsule. The system 1 comprises a capsule 2 that is sealed so as to be sealed, and a beverage preparation device 4. The device 4 comprises enclosing member 6 for holding the capsule 2. The device 4 further comprises a closing member, such as an extraction plate, 8 for supporting the capsule 2.

[0044] In Fig. 1 a gap is drawn between the capsule 2, the enclosing member 6 and the extraction plate 8 for clarity. It will be appreciated that, in use, the capsule 2 may lie in contact with the enclosing member 6 and the extraction plate member 8. Commonly, the enclosing member 6 has a shape complementary to the shape of the capsule 2. The apparatus 4 further comprises a fluid injection means 10 for supplying an amount of a fluid, such as water, under a pressure in the range of 6-20 bar, preferably between 12 and 18 bar, to the exchangeable capsule 2.

[0045] In the example shown in Fig. 1, the exchangeable capsule 2 comprises an aluminum capsule body 12 having a central capsule body axis 12A and an aluminum cover 14. In this example, the aluminum capsule body 12 comprises a side wall 16, a bottom 18 closing the side wall 16 at a first end, and a outwardly extending flange 20 extending outwardly of the circumferential wall 16 at a second end opposite the bottom 18. The side wall 16, the bottom 18 and the cover 14 enclose an inner space 22 comprising a substance for the preparation of a potable beverage by extracting and/or dissolving the substance. Preferably the substance is 5-20 grams, preferably 5-10 grams, more preferably 5-7 grams of an extractable product, such as roasted and ground coffee for the preparation of a single beverage. The capsule is initially sealed, i.e. is sealed prior to use.

[0046] The system 1 of Fig. 1 comprises bottom piercing means 24 for piercing the bottom 18 of the capsule 2 for creating at least one entrance opening 25 in the bottom 18 for supplying the fluid to the extractable product through the entrance opening 25.

[0047] The system 1 of Fig. 1 further comprises cover piercing means 26, here embodied as protrusions of the closing member 8, for piercing the cover 14 of the capsule 2. The cover piercing means 26 may be arranged to tear the cover 14 once a (fluid) pressure inside the inner space 22 exceeds a threshold pressure and presses the cover 14 against the cover piercing means 26 with sufficient force. The aluminum cover 14 thus is arranged to tear open on the closing member 8 of the beverage preparation device under the influence of fluid pressure in the capsule.

[0048] The capsule 2 further comprises a sealing structure 28, in Figures 1, 3A and 3B indicated as a general box but more detailed described with reference to Figures 4A-4H, which sealing structure 28 is arranged at the outwardly extending flange 20 for providing a fluid sealing contact with the enclosing member 6 if the capsule 2 is positioned in the enclosing member 6 and the enclosing member 6 is closed by means of the extraction plate 8, such that the outwardly extending flange 20 of the capsule 2 and at least a portion of the sealing structure 28 are sealingly engaged between the enclosing member 6 and the extraction plate 8.

[0049] As shown in Figure 2 the enclosing member 6 of the beverage preparation device comprises an annular element 41 having a central annular element axis 41A and a free annular end surface 30. The annular end surface 30 of the annular element 41 is provided with a plurality of radially extending open grooves 40. The plurality of radially extending open grooves 40 are uniformly spaced relative to each other in tangential direction of the annular end surface 30 of the annular element 41. The longest tangential width of each groove 40 is 0.9 - 1.1 mm, preferably 0.95 to 1.05 mm, more preferably 0.98 to 1.02 mm, wherein a maximal height of each groove 40 in an axial direction of the enclosing member 6 is 0.01 - 0.09 mm, preferably 0.03 to 0.07 mm, more preferably 0.045 to 0.055 mm, and most preferred 0.05 mm. The number of grooves 40 lies in the range of 90 to 110, preferably 96. The radial width of the annular end surface at the location of the grooves may for instance be 0.05- 0.9 mm, preferably 0.2- 0.7 mm and more preferably 0.3 - 0.55 mm.

[0050] An embodiment of a capsule according to the invention is shown more detailed in Figures 3A and 3B. In the shown embodiment the outer diameter ODF of the outwardly extending flange 20 is larger than the diameter DB of the bottom 18 of the capsule 2. In the shown embodiment the outer diameter ODF of the outwardly extending flange 20 is approximately 37.1 mm and the diameter DB of the bottom 18 is about 23.3 mm. In the present example, the wall thickness of the aluminum capsule body 12 is 100 micrometer. Generally, a wall thickness of, depending on various considerations, 20 to 200 micrometer is preferred.

[0051] In the shown embodiment the thickness of the aluminum cover 14 is 39 micrometer, preferred thickness ranging from 15-65 micrometer and more in particular 30-45 micrometer. Preferably the thickness of the aluminum cover 14 is smaller than the thickness of the aluminum capsule body 12.

[0052] The side wall 16 of the aluminum capsule body 12 has a free end 42 opposite the bottom 18. The inner diameter IDF of the free end 42 of the side wall 16 of the aluminum capsule body 12 is about 29.5 mm. The outwardly extending flange 20 extends from that free end 42 in a direction at least substantially transverse to the central capsule body axis 12A. The outwardly extending flange 20 comprises a curled outer edge 43 which is beneficial for obtaining a seal between the capsule and the enclosing member. In the shown embodiment the curled outer edge 43 of the outwardly extending flange 20 has a largest dimension of about 1.2 millimeter. The distance DIF between the free end 42 of the side wall 16 of the aluminum capsule body 12 and an inner edge 43A of the curled outer edge 43 is about 2.7 mm, while the distance DOF between the free end 42 of the side wall 16 of the aluminum capsule body 12 and an outermost edge 43B

of the outwardly extending flange 20 is about 3.8 millimeter.

[0053] As shown in Figures 3A and 3B the sealing structure 28 is positioned between the free end of the side wall 16 of the aluminum capsule body 12 and the inner edge 43A of the curled outer edge 42 of the outwardly extending flange. The sealing structure 28 is indicated as a general box, but will be described in more detail below. Irrespective of the embodiment of the sealing structure 28 the height of the sealing structure is preferably at least about 0.1 mm, more preferably at least 0.2 mm and most preferably at least 0.8 mm and at most 3 mm, more preferably at most 2 mm and most preferably at most 1.2 mm for providing a correct seal.

[0054] As can be seen from Figure 3A the aluminum capsule body 12 is truncated. In the embodiment shown, the side wall 16 of the aluminum capsule body 12 encloses an angle A with a line transverse to the central capsule body axis 12A of about 97.5°. The bottom 18 of the aluminum capsule body 12 has a largest inner diameter DB of about 23.3 mm. The bottom 18 of the aluminum capsule body 12 is also truncated, and in the shown embodiment has a bottom height BH of about 4.0 mm. The bottom 18 further has a generally flat central portion 18A opposite the cover 14, which central portion 18A has a diameter DEE of about 8.3 mm and in which central portion 18A the entrance opening(s) 25 may be made. The entrance openings may also be made in the truncated portion between the central portion 18A and the side wall 16. The total height TH of the aluminum capsule body 12 of the capsule is about 28.4 mm.

[0055] The system 1 shown in Fig. 1 is operated as follows for preparing a cup of a potable beverage, in the present example coffee the substance in the capsule being roasted and ground coffee.

[0056] The capsule 2 is placed in the enclosing member 6. The extraction plate 8 is brought into contact with the capsule 2. The bottom piercing means 24 pierce the bottom 18 of the capsule 2 for creating the entrance openings 25. The fluid, here hot water under pressure, is supplied to the extractable product in the inner space 22 through the entrance openings 25. The water will wet the coffee grounds and extract the desired substances to form the coffee beverage.

[0057] During supplying the water under pressure to the inner space 22, the pressure inside the capsule 2 will rise. The rise in pressure will cause the cover 14 to deform and be pressed against the lid piercing means 26 of the extraction plate. Once the pressure reaches a certain level, the tear strength of the cover 14 will be surpassed and the cover 14 will rupture against the lid piercing means 26, creating exit openings. The prepared coffee will drain from the capsule 2 through the exit openings and outlets 32 (see Fig. 1) of the extraction plate 8, and may be supplied to a container such as a cup (not shown).

[0058] The system 1 is arranged such that prior to or at the start of brewing, the free end 30 of the enclosing member 6 exerts a force F 1 on the sealing structure 28 of the capsule 2 to provide a sealing contact between the outwardly extending flange 20 of the capsule 2 and the enclosing member 6 of the beverage preparation device, wherein the force F1 is in the range of 30-150 N, preferably 40-150 N and more preferably 50-100N, when the fluid pressure P1 in the enclosing member of the beverage preparation device outside the capsule is in the range of 0.1-4 bar, preferably 0.1-1 bar. During brewing, the free end 30 of the enclosing member 6 exerts a force F2 on the sealing structure 28 of the capsule 2 to provide a sealing contact between the outwardly extending flange 20 of the capsule 2 and the enclosing member 6, wherein the force F2 is in the range of 500 -1500 N, preferably in the range of 750-1250 N, when the fluid pressure P2 in the enclosing member 6 of the beverage preparation device outside the capsule 2 is in the range of 6-20 bar, preferably between 12 and 18 bar. In the shown embodiment a part 6B of the enclosing member 6 can move relative to the extracting plate 8 under the effect of the pressure of the fluid in the enclosing member 6 device towards the extraction plate 8 for applying the maximum force between the outwardly extending flange 20 and the free end 30 of the enclosing member 6. This movement can take place during use, i.e. at the start of brewing and during brewing. The enclosing member 6 has a first part 6A and a second part 6B wherein the second part comprises the annular end surface 30. The second part 6B can move relative to the first part 6A between a first and second position. The second part 6B can move from the first positon towards the second position in the direction of the closing member 8 under the influence of fluid pressure in the enclosing member 6. The force F1 as discussed above may be reached if the second part 6B is in the first position with a fluid pressure P1. The force F2 as discussed above may be reached if the second part 6B is moved towards the second position under the influence of the fluid pressure P2 in the enclosing member 6.

[0059] As a result of the force applied the sealing structure 28 of the capsule according to the invention undergoes a plastic deformation and closely conforms to the grooves 40 of the annular end surface 30 and thus provides a sealing contact between the enclosing member 6 and the capsule 3 at a relatively low fluid pressure during start up of brewing but also provides a sealing contact at the much higher fluid pressure in the enclosing member outside the capsule during brewing. This close conformation to the grooves 40 of the enclosing member is indicated in Figure 3C which shows the capsule 2 of the invention after use, and which clearly indicates that the outwardly extending flange 20 comprises deformations 40' which conform to the grooves 40 of the enclosing member.

[0060] Now exemplary embodiments of a sealing structure 28 at the outwardly extending flange 20 of the capsule 2 according to the invention will be described in more detail with regard to Figs. 4A to 4H. In Fig. 4A, a first example of flange 20 with a sealing structure 28 in

contact with an annular end surface of an enclosing member 6 prior to deformation of the sealing structure 28 is shown. The sealing structure is in the form of a deformable sealing ring portion 28 of the flange 20. The cover 14 is attached to base portions 44, 45 of the flange 20, which define a flat base level plane of the flange 20 perpendicular to the capsule body axis. The sealing ring portion 28 projects axially from the base portions 44, 45 of the flange 20 on a side of the base portions 44, 45 opposite of the cover 14 (i.e. the side facing the annular end surface 30).

The deformable sealing ring portion 28 has an inner wall portion 46 extending from and contiguous with an inner base portion 44 of the flange 20 and an outer wall portion 47 extending from and contiguous with an outer base portion 45 of the flange 20. The outer wall portion 47 is located outward of and spaced from the inner wall portion 46. The deformable sealing ring portion 28 further includes a bridge portion 48 interconnecting the inner wall portion 46 and the outer wall portion 47. The bridge portion 48 is located axially spaced from the base portions 44, 45 of the flange 20. In the cross-sectional view as shown, a top 49 of the bridge portion axially most remote from the base portions of the flange 44, 45 has a center plane curved with a radius of curvature larger than two times the wall thickness of the top 49 of the bridge portion 48. Because the radius of curvature is relatively large, it can be deformed relatively easily to accommodate to the shape of the annular end surface 30 as the annular end surface 30 is pressed against the deformable sealing ring portion 28 causing it to be deformed. Since the deformable sealing ring portion 28 is an integral portion of the capsule body, it can be manufactured efficiently and, being of the same material as the rest of the capsule body, it can be recycled together with the rest of the capsule body after use and disposal of the capsule.

[0061] The inner wall portion 46 is oriented at a different angle to the base portions of the flange 44, 45 than the outer wall portion 47. This results in accurate and reliable deformation of the sealing structure 28 to a predetermined shape during sealing. In particular, it is avoided that transitions between circumferential sections deforming to different end shapes are formed during deformations. Such transitions entail an increased risk of leakage.

[0062] In the present example, this effect is achieved particularly effectively because the outer wall portion extends at an oblique angle relative to a plane of the associated contiguous base portion of the flange and the inner wall portion extends from the associated contiguous base portion of the flange at an opposite angle, so that it is parallel to the outer wall portion 47. The oblique angle is preferably 20-60°, and more preferably 30-50°, and the opposite angle is preferably 120-160°, and more preferably 110-150° relative to a plane of the respective, associated contiguous base portions of the flange 44, 45.

[0063] In the example shown in Fig. 4B, the outer wall portion 147 is about perpendicular the base portion of the flange contiguous therewith. In addition to a curved portion including the top portion 149, the bridge portion 148 also has an oblique, generally flat portion 150. For a smooth, accurate and reliable deformation to a predetermined shape, the inner wall portions 146 has a curved center plane contiguous to the curvature of the top of said bridge portion. The relatively easy compressibility of the curved inner wall portion 146 is accommodated by a generally hinging deflection of the flat portion 150 of the bridge portion about its connection to the outer wall portion 147. Thus, it is avoided that the inner wall portion 146 and an adjacent portion of the bridge portion 148 are folded flat to one side and ensured that the curved sections formed by these portions is folded onto itself during deformation, thereby ensuring that during deformation a relatively constant counterforce is exerted.

[0064] In Fig. 4C, an example is shown in which the top 249 of the bridge portion 248 is flat (i.e. has an infinitely large radius of curvature). Also, such a flat wall portion is deformable relatively easily for smooth accommodation to the shape of the annular end surface 30. The inner and outer wall portions 246, 247 are oriented perpendicularly to the adjacent base portions of the flange 244, 245, so that a particularly stiff support of the bridge portion 248 is obtained, which prevents the bridge portion from being displaced as a whole as a result of the pressure exerted by the annular end surface 30, so deformations are, at least initially, concentrated in the bridge portion 248 itself. In turn, this is advantageous for accommodation of the shape of the sealing ring portion 228 to the shape of the annular end surface 30. A particularly effective and reliable sealing already at low sealing pressure can be achieved if at least a portion of the top 249 of the bridge portion 248 has a reduced wall thickness smaller than a wall thickness of the inner and outer wall portions 247, 246 (the reduced wall thickness is not shown in Fig. 4C). In this and other embodiments, the reduced thickness may of at least the top portion of the bridge portion may for instance be 10 - 95 micrometer, more preferably 30 - 70 micrometer, most preferably 40 - 50 micrometer.

[0065] In the example shown in Fig. 4D, the deformable sealing ring portion is Ω shaped, the inner wall portion 346, the bridge portion 348 with top 349 and the outer wall portion 347 having an essentially constant radius of curvature. Such a shape is particularly advantageous for a smooth, accurate and reliable deformation to a predetermined shape. Another advantage of such a shape is that only a small gap is left between inner and outer base portions of the flange 344, 345 so that a large surface area for adherence of the cover 14 to the flange is left.

[0066] Also in the example shown in Fig. 4D, the deformable sealing ring portion 428 is Ω shaped, but has a larger radius of curvature, such that the width of the Ω shaped portion is at least as wide as the width of the annular end surface 30. This allows the annular end surface to be pressed into the (originally) Ω shaped portion, of which the width increases during deformation, so that a particularly effective double sealing is achieved at outer

and inner border areas of annular end surface 30.

[0067] In the example shown in Fig. 4F, a support member 551 of a relatively resilient material is provided between the inner and outer wall portions 546, 547 and under the bridge portion 548 for obtaining a high counter pressure during a final stage of deformation of the sealing structure. Such a support member is particularly advantageous if, as in the present example, the deformable sealing ring portion 528 is of a relatively flat configuration.

[0068] A particularly good conformability to the shape of the annular end surface 30 and accordingly a particularly effective and reliable sealing already at low sealing pressure can be achieved if, as in the example shown in Fig. 4G, at least a portion of the top 649 of the bridge portion 648 has a reduced wall thickness smaller than a wall thickness of the inner and outer wall portions 647, 646.

[0069] The bridge portion 649 may have an uncoated surface facing the annular end surface 30 whereas the rest of the capsule body material may be coated on the same side or on both sides, to avoid damage to the coating during reduction of the wall thickness or by removing the coating while reducing the wall thickness. While the coating is removed, a texture may be applied to the surface from which the coating is removed. Such a texture, preferably including ridges and valleys in circumferential sense of the flange, can further improve the conformability during early stages of clamping, when the sealing pressure is still low, because clamping force is transferred via raised portions of the texture only, so that at the raised portions a higher contact pressure is exerted than would be exerted over a full smooth contact surface.

[0070] In Fig. 4H, an example is shown in which one of the wall portions 746, 747 (in this case the outer wall portion 747) is oriented more steeply relative to the base portions of the flange 744, 745 than the other one of the wall portions 746, 747 (in this case the inner wall portion 747), which is oriented obliquely relative to the base portions of the flange 744, 745. Also in this example, the oblique wall portion 746, which pivots as it follows deformation of the bridge portion 748 and of the steep wall portion 747, prevents the steep wall portion 747 that is deformed most from folding over. The steep outer wall portion 747 is positioned, such that it is deflected to the outside of the annular end surface 30 as the enclosing member is pushed against the top portion 749 of the bridge portion. The wall material of a top end of the steep outer wall portion 747 is then deformed in a rolling off fashion as it follows the bridge portion 748 that is pushed down and radially held by the pivoting inner wall portion 746, as is illustrated by the deformed conditions 728' and 728" of the deformable sealing portion 728 shown in Fig. 4H. Thus, initially a local deformation accommodating to the shape of the annular end surface 30 is achieved when the annular end surface 30 is pressed against the top portion 749 of the bridge portion 748. Subsequently, the deformation in a rolling off fashion allows smooth axial deformation over a large trajectory.

[0071] In each of the examples shown in Fig. 4A-4H, the top of the bridge portion is positioned for being contacted first by the annular end portion 30, when the sealing ring portion is clamped between the annular end surface and the closing member of a compatible beverage preparation device. The diameter of the top of the bridge portion is moreover such that the top of the bridge portion is located centrally relative to the annular end surface 30 for first contacting a central portion of that annular end surface when the sealing ring portion is clamped between the annular end surface and said closing member of a compatible beverage preparation device.

[0072] In the foregoing specification, the invention has been described with reference to specific examples of embodiments of the invention. It will, however, be evident that various modifications and changes may be made therein without departing from the broader scope of the invention as set forth in the appended claims.

Claims

1. A capsule (2) containing a substance for the preparation of a potable beverage by extracting and/or dissolving the substance by means of supplying a fluid under pressure into the capsule, said capsule comprising:

an aluminum capsule body (12) having a central capsule body axis (12A), said aluminum capsule body (12) comprising a bottom (18), a side wall (16), an outwardly extending flange (20) and a sealing structure at said flange (20); and
a cover sheet (14) attached to said flange (20) and hermetically closing off the capsule (2);
wherein said sealing structure is deformable for providing a fluid sealing contact with an annular end surface (30) of an enclosing member (6) of a beverage preparation device if the capsule is positioned in said enclosing member (6) and said enclosing member (6) is closed by means of a closing member (8) of the beverage preparation device, such as an extraction plate of the beverage preparation device, at least portions of said flange (20) and said sealing structure being clamped between said annular end surface (30) and said closing member (8), said annular end surface (30) optionally being provided with a plurality of radially extending open grooves (40);
wherein said sealing structure includes a deformable sealing ring portion (28) of said flange (20), said sealing ring portion (28) projecting axially from base portions (44, 45) of said flange (20), to which said cover sheet (14) is attached, on a side of said base portions (44, 45) opposite of said cover sheet (14), said deformable sealing ring portion (28) comprising:

an inner wall portion (46) extending from and contiguous with an inner base portion (44) of said flange (20);
an outer wall portion (47) extending from and contiguous with an outer base portion (45) of said flange (20), said outer wall portion (47) being located radially outward of and radially spaced from said inner wall portion (46); and
a bridge portion (48) interconnecting said inner wall portion (46) and said outer wall portion (47), said bridge portion (48) being located axially spaced from said base portions (44, 45) of said flange (20);

wherein, in radial cross-sectional view, a top of said bridge portion (48) axially most remote from said base portions (44, 45) of the flange (20) is curved with a radius of curvature larger than two times a wall thickness of said top of said bridge portion (48); and
wherein said outer wall portion (47) extends at an oblique angle relative to a plane of the associated contiguous base portion (45) of the flange (20) and said inner wall portion (46) extends from the associated contiguous base portion (44) of the flange 20) at a steeper or opposite angle relative to a plane of the associated contiguous base portion of the flange (20);
characterized in that, in cross-sectional view, at least a portion of said inner wall portion (46) is curved and said curved portion of said inner wall portion (46) is contiguous to the curvature of said top of said bridge portion (48).

2. A capsule according to claim 1, wherein at least a portion of the top of said bridge portion (48) has a reduced wall thickness smaller than a wall thickness of said inner and outer wall portions (47, 48).

3. A capsule according to claim 2, further comprising a coating to at least one side of said capsule body (12), said coating being absent in at least said portion of the top of said bridge portion (48) having a reduced wall thickness.

4. A capsule according to claim 3, wherein said uncoated portion of said bridge portion (48) is on a side of said flange (20) opposite of said cover sheet (14) and has a textured surface.

5. A capsule according to claim 4, wherein said textured surface includes ridges and valleys extending in circumferential sense of said flange (20).

6. A capsule according to any of the preceding claims, wherein said outer wall portion (47) extends at an oblique angle of 20-60° relative to a plane of the associated contiguous base portion (45) of the flange (20) and the said inner wall portion (46) extends from the associated contiguous base portion (44) of the flange (20) at an angle of 60-160°, relative to said plane of the associated contiguous base portion of the flange (20).

7. A capsule according to any of the preceding claims, wherein, in cross-sectional view, at least a portion of said outer wall portion (47) has a curved center plane.

8. A capsule according to claim 7, wherein said curved portion of said at least one of said inner and outer wall portions (46, 47) is contiguous to the curvature of said top of said bridge portion (48).

9. A capsule according to claim 8, wherein, in cross-sectional view said deformable sealing ring portion (28) is Ω shaped.

10. A capsule according to any of the preceding claims, further comprising a support member between said inner and outer wall portions (46, 47).

11. A capsule according to any of the preceding claims, wherein said top of said bridge portion (48) is positioned for being contacted first by said annular end portion (30), when said sealing ring portion (28) is clamped between said annular end surface (30) and said closing member (8) of a compatible beverage preparation device.

12. A capsule according to claim 11, wherein said top of said bridge portion (48) forms a crest extending circumferentially about the center line of the capsule (2), said crest having a diameter of 29-33 mm, more preferably 30.0-31.4 mm and most preferably 30.3-31.0 mm.

13. A capsule according to any of the preceding claims, wherein the sealing ring portion (28) and the remainder of the capsule body (12) are made of the same plate material.

14. A system for preparing a potable beverage from a capsule (2) using a fluid supplied under pressure into the capsule (2) comprising:

a beverage preparation device comprising an enclosing member (6) for receiving the capsule (2), wherein the enclosing member (6) comprises fluid injection means for supplying fluid under pressure into the capsule (2), wherein the beverage preparation device further comprises a closing member (8), such as an extraction plate, for closing the enclosing member (6) of the beverage preparation device, wherein said enclos-

ing member (6) has an annular end (30) with an annular end surface, said annular end surface (30 optionally being provided with a plurality of radially extending open grooves (40);
a capsule (2) containing a substance for the preparation of a potable beverage by extracting and/or dissolving the substance by means of supplying a fluid under pressure into the capsule (2), said capsule (2) comprising:

an aluminum capsule body (12) having a central capsule body axis (12A), said aluminum capsule body (12) comprising a bottom (18), a side wall (16), an outwardly extending flange (20) and a sealing structure at said flange (20); and
a cover sheet (14) attached to said flange (20) and hermetically closing off the capsule (2);

wherein said sealing structure is deformable and in fluid sealing contact with said annular end surface (30) if the capsule (2) is positioned in said enclosing member (6) and said enclosing member (6) is closed by means of said closing member (8), at least portions of said flange (20) and said sealing structure being clamped between said annular end surface (30) and said closing member (8);
wherein said sealing structure includes a deformable sealing ring portion (28) of said flange (20), said sealing ring portion (28) projecting axially from base portions (44, 45) of said flange (20), to which said cover sheet (14) is attached, on a side of said base portions (44, 45) facing said enclosing member when said capsule (2) is in said enclosing member (6), said deformable sealing ring portion (28) comprising:

an inner wall portion (46) extending from and contiguous with an inner base portion (44) of said flange (20);
an outer wall portion (47) extending from and contiguous with an outer base portion (45) of said flange (20), said outer wall portion (47) being located radially outward of and radially spaced from said inner wall portion (46); and
a bridge portion (48) interconnecting said inner wall portion (46) and said outer wall portion (47), said bridge portion (48) being located axially spaced from said base portions (44, 45) of said flange (20);

wherein, in radial cross-sectional view, a top of said bridge portion(48) axially most remote from said base portions (44, 45) of the flange (20) is flat or has a center plane curved with a radius of curvature larger than two times a wall thickness of said top of said bridge portion (48); and wherein said outer wall portion (47) extends at an oblique angle relative to a plane of the associated contiguous base portion (45) of the flange (20) and said inner wall portion (46) extends from the associated contiguous base portion (44) of the flange 20) at a steeper or opposite angle relative to a plane of the associated contiguous base portion of the flange (20);
characterized in that, in cross-sectional view, at least a portion of said inner wall portion (46) has a curved center plane.

15. A system according to claim 14, wherein said annular end surface (30) is positioned for first contacting said top of said bridge portion (48) when said sealing ring portion (28) is clamped between said annular end surface (30) and said closing member (8).

16. A system according to claim 15, wherein, in cross-sectional view, said top of said bridge portion (48) is located centrally relative to said annular end surface (30) for first contacting a central portion of said annular end surface (30) when said sealing ring portion (28) is clamped between said annular end surface (30) and said closing member (8).

17. A system according to any of the claims 14-16, wherein the capsule (2) is a capsule according to any of the claims 2-13.

18. Use of a capsule (2) according to any one of the claims 1 to 13 in a beverage preparation device comprising an enclosing member (6) for receiving the capsule (2), wherein the enclosing member (6) comprises fluid injection means supplying fluid under pressure into the capsule (2), wherein the beverage preparation device further comprises a closing member (8), such as an extraction plate, closing the enclosing member (6) of the beverage preparation device, wherein said enclosing member (6) has an annular end with an annular end surface (30), said annular end surface (30) optionally being provided with a plurality of radially extending open grooves (40), wherein the capsule (2) is positioned in the enclosing member (6) of the beverage preparation device, the enclosing member (6) is closed by means of the closing member (8) of the beverage preparation device, and at least a portion of the sealing structure is clamped between the enclosing member (6) and the closing member (8) of the beverage preparation device causing the sealing structure to be brought in sealing contact with the annular end surface (30).

19. A method of manufacturing a capsule body (2) of a capsule according to any of the claims 3-5, starting from a semi finished deep drawn cup member, the

method comprising reducing a wall thickness of a portion of said flange (20) for forming said portion of said top of said bridge portion (48) having a reduced wall thickness smaller than a wall thickness of said inner and outer wall portions (46, 47), wherein said coating is removed from said portion of said flange of which the wall thickness is to be reduced prior to or during reducing the wall thickness.

Patentansprüche

1. Kapsel (2), die eine Substanz zum Herstellen eines trinkbaren Getränks durch Extrahieren und/oder Auflösen der Substanz mittels Zuführen eines unter Druck stehenden Fluids in die Kapsel enthält, wobei die Kapsel Folgendes umfasst:

einen Aluminiumkapselkörper (12) mit einer zentralen Kapselkörperachse (12A), wobei der Aluminiumkapselkörper (12) einen Boden (18), eine Seitenwand (16), einen sich nach außen erstreckenden Flansch (20) und eine Dichtungsstruktur an dem Flansch (20) umfasst; und
eine Abdeckfolie (14), die an dem Flansch (20) befestigt ist und die Kapsel (2) hermetisch verschließt;
wobei die Dichtungsstruktur verformbar ist, um einen Fluiddichtungskontakt mit einer ringförmigen Endoberfläche (30) eines Umschließungselements (6) einer Getränkezubereitungsvorrichtung bereitzustellen, wenn die Kapsel in dem Umschließungselement (6) positioniert ist und das Umschließungselement (6) mittels eines Schließelements (8) der Getränkezubereitungsvorrichtung geschlossen wird, wie beispielsweise eine Extraktionsplatte der Getränkezubereitungsvorrichtung, wobei zumindest Abschnitte des Flansches (20) und der Dichtungsstruktur zwischen der ringförmigen Endoberfläche (30) und dem Schließelement (8) eingespannt sind, wobei die ringförmige Endoberfläche (30) wahlweise mit einer Vielzahl von radial verlaufenden offenen Nuten (40) versehen ist;
wobei die Dichtungsstruktur einen verformbaren Dichtungsringabschnitt (28) des Flansches (20) einschließt, wobei der Dichtungsringabschnitt (28) axial von den Basisabschnitten (44, 45) des Flansches (20), an denen die Abdeckfolie (14) befestigt ist, auf einer Seite der Basisabschnitte (44, 45) gegenüber der Abdeckfolie (14) vorsteht, wobei der verformbare Dichtungsringabschnitt (28) Folgendes umfasst:

einen Innenwandabschnitt (46), der von einem inneren Basisabschnitt (44) des Flansches (20) aus verläuft und an diesen angrenzt;
einen Außenwandabschnitt (47), der von einem äußeren Basisabschnitt (45) des Flansches (20) aus verläuft und an diesen angrenzt, wobei der Außenwandabschnitt (47) radial nach außen und radial von dem Innenwandabschnitt (46) beabstandet angeordnet ist; und
einen Brückenabschnitt (48), der den Innenwandabschnitt (46) und den Außenwandabschnitt (47) verbindet, wobei der Brückenabschnitt (48) axial beabstandet von den Basisabschnitten (44, 45) des Flansches (20) angeordnet ist;
wobei in einer radialen Querschnittansicht eine Oberseite des Brückenabschnitts (48), die axial am weitesten von den Basisabschnitten (44, 45) des Flansches (20) entfernt ist, mit einem Krümmungsradius gekrümmt ist, der mehr als doppelt so groß wie die Wanddicke der Oberseite des Brückenabschnitts (48) ist; und
wobei der Außenwandabschnitt (47) in einem schrägen Winkel relativ zu einer Ebene des zugehörigen angrenzenden Basisabschnitts (45) des Flansches (20) verläuft und der Innenwandabschnitt (46) von dem zugehörigen angrenzenden Basisabschnitt (44) des Flansches (20) in einem steileren oder entgegengesetzten Winkel relativ zu einer Ebene des zugehörigen angrenzenden Basisabschnitts des Flansches (20) verläuft;

dadurch gekennzeichnet, dass in der Querschnittsansicht mindestens ein Abschnitt des Innenwandabschnitts (46) gekrümmt ist und der gekrümmte Abschnitt des Innenwandabschnitts (46) an die Krümmung der Oberseite des Brückenabschnitts (48) angrenzt.

2. Kapsel nach Anspruch 1, wobei mindestens ein Abschnitt der Oberseite des Brückenabschnitts (48) eine reduzierte Wanddicke aufweist, die kleiner ist als eine Wanddicke des Innen- und Außenwandabschnitts (47, 48).

3. Kapsel nach Anspruch 2, ferner umfassend eine Beschichtung auf mindestens einer Seite des Kapselkörpers (12), wobei die Beschichtung in mindestens dem Abschnitt der Oberseite des Brückenabschnitts (48), der eine reduzierte Wanddicke aufweist, fehlt.

4. Kapsel nach Anspruch 3, wobei der unbeschichtete Abschnitt des Brückenabschnitts (48) sich auf einer Seite des Flansches (20) gegenüber der Abdeckfolie (14) befindet und eine texturierte Oberfläche aufweist.

5. Kapsel nach Anspruch 4, wobei die texturierte Oberfläche Erhöhungen und Täler einschließt, die in Umfangsrichtung des Flansches (20) verlaufen.

6. Kapsel nach einem der vorstehenden Ansprüche, wobei der Außenwandabschnitt (47) in einem schrägen Winkel von 20° bis 60° relativ zu einer Ebene des zugehörigen angrenzenden Basisabschnitts (45) des Flansches (20) verläuft und der Innenwandabschnitt (46) von dem zugehörigen angrenzenden Basisabschnitt (44) des Flansches (20) in einem Winkel von 60° bis 160° relativ zu der Ebene des zugehörigen angrenzenden Basisabschnitts des Flansches (20) verläuft.

7. Kapsel nach einem der vorstehenden Ansprüche, wobei in der Querschnittsansicht mindestens ein Abschnitt des Außenwandabschnitts (47) eine gekrümmte Mittelebene aufweist.

8. Kapsel nach Anspruch 7, wobei der gekrümmte Abschnitt des mindestens einen der Innen- und Außenwandabschnitte (46, 47) an die Krümmung der Oberseite des Brückenabschnitts (48) angrenzt.

9. Kapsel nach Anspruch 8, wobei in der Querschnittsansicht der verformbare Dichtungsringabschnitt (28) Q-förmig ist.

10. Kapsel nach einem der vorstehenden Ansprüche, ferner umfassend ein Stützelement zwischen dem Innen- und Außenwandabschnitt (46, 47).

11. Kapsel nach einem der vorstehenden Ansprüche, wobei die Oberseite des Brückenabschnitts (48) so positioniert ist, dass sie zuerst durch den ringförmigen Endabschnitt (30) berührt wird, wenn der Dichtungsringabschnitt (28) zwischen der ringförmigen Endoberfläche (30) und dem Schließelement (8) einer kompatiblen Getränkezubereitungsvorrichtung eingespannt ist.

12. Kapsel nach Anspruch 11, wobei die Oberseite des Brückenabschnitts (48) einen Scheitel bildet, der um die Mittellinie der Kapsel (2) herum verläuft, wobei der Scheitel einen Durchmesser von 29 bis 33 mm, mehr bevorzugt 30,0 bis 31,4 mm und am meisten bevorzugt 30,3 bis 31,0 mm aufweist.

13. Kapsel nach einem der vorstehenden Ansprüche, wobei der Dichtungsringabschnitt (28) und der Rest des Kapselkörpers (12) aus dem gleichen Plattenmaterial hergestellt sind.

14. System zum Herstellen eines trinkbaren Getränks aus einer Kapsel (2) unter Verwendung eines unter Druck stehenden, in die Kapsel (2) zugeführten Fluids, Folgendes umfassend:

eine Getränkezubereitungsvorrichtung, umfassend ein Umschließungselement (6) zum Aufnehmen der Kapsel (2), wobei das Umschließungselement (6) Fluideinspritzmittel zum Zuführen von unter Druck stehendem Fluid in die Kapsel (2) umfasst, wobei die Getränkezubereitungsvorrichtung ferner ein Schließelement (8), wie beispielsweise eine Extraktionsplatte, zum Verschließen des Umschließungselements (6) der Getränkezubereitungsvorrichtung umfasst, wobei das Umschließungselement (6) ferner ein ringförmiges Ende (30) mit einer ringförmigen Endoberfläche aufweist, wobei die ringförmige Endoberfläche (30) wahlweise mit einer Vielzahl von sich radial erstreckenden offenen Nuten (40) versehen ist;
eine Kapsel (2), enthaltend eine Substanz zum Herstellen eines trinkbaren Getränks durch Extraktion und/oder Auflösen der Substanz mittels Zuführen eines unter Druck stehenden Fluids in die Kapsel (2), wobei die Kapsel (2) Folgendes umfasst:

einen Aluminiumkapselkörper (12) mit einer zentralen Kapselkörperachse (12A), wobei der Aluminiumkapselkörper (12) einen Boden (18), eine Seitenwand (16), einen sich nach außen erstreckenden Flansch (20) und eine Dichtungsstruktur an dem Flansch (20) umfasst; und
eine Abdeckfolie (14), die an dem Flansch (20) befestigt ist und die Kapsel (2) hermetisch verschließt;

wobei die Dichtungsstruktur verformbar ist und im Fluiddichtungskontakt mit der ringförmigen Endoberfläche (30) steht, wenn die Kapsel (2) in dem Umschließungselement (6) positioniert ist und das Umschließungselement (6) mittels des Schließelements (8) geschlossen wird, wobei zumindest Abschnitte des Flansches (20) und der Dichtungsstruktur zwischen der ringförmigen Endoberfläche (30) und dem Schließelement (8) eingespannt sind;
wobei die Dichtungsstruktur einen verformbaren Dichtungsringabschnitt (28) des Flansches (20) einschließt, wobei der Dichtungsringabschnitt (28) axial von den Basisabschnitten (44, 45) des Flansches (20), an denen die Abdeckfolie (14) befestigt ist, auf einer Seite der Basisabschnitte (44, 45) vorsteht, die dem Umschließungselement zugewandt ist, wenn sich die Kapsel (2) in dem Umschließungselement (6) befindet, wobei der verformbare Dichtungsringabschnitt (28) Folgendes umfasst:
einen Innenwandabschnitt (46), der von einem inneren Basisabschnitt (44) des Flansches (20) aus verläuft und an diesen angrenzt;

einen Außenwandabschnitt (47), der von einem äußeren Basisabschnitt (45) des Flansches (20) aus verläuft und an diesen angrenzt, wobei der Außenwandabschnitt (47) radial nach außen und radial von dem Innenwandabschnitt (46) beabstandet angeordnet ist; und
einen Brückenabschnitt (48), der den Innenwandabschnitt (46) und den Außenwandabschnitt (47) verbindet, wobei der Brückenabschnitt (48) axial beabstandet von den Basisabschnitten (44, 45) des Flansches (20) angeordnet ist;
wobei in radialer Querschnittsansicht eine Oberseite des Brückenabschnitts (48), die axial am weitesten von den Basisabschnitten (44, 45) des Flansches (20) entfernt ist, flach ist oder eine Mittelebene aufweist, die mit einem Krümmungsradius gekrümmt ist, der mehr als doppelt so groß wie einer Wanddicke der Oberseite des Brückenabschnitts (48) ist; und
wobei der Außenwandabschnitt (47) in einem schrägen Winkel relativ zu einer Ebene des zugehörigen angrenzenden Basisabschnitts (45) des Flansches (20) verläuft und der Innenwandabschnitt (46) von dem zugehörigen angrenzenden Basisabschnitt (44) des Flansches (20) in einem steileren oder entgegengesetzten Winkel relativ zu einer Ebene des zugehörigen angrenzenden Basisabschnitts des Flansches (20) verläuft;
dadurch gekennzeichnet, dass in der Querschnittsansicht mindestens ein Abschnitt des Innenwandabschnitts (46) eine gekrümmte Mittelebene aufweist.

15. System nach Anspruch 14, wobei die ringförmige Endoberfläche (30) so angeordnet ist, dass sie zuerst die Oberseite des Brückenabschnitts (48) berührt, wenn der Dichtungsringabschnitt (28) zwischen der ringförmigen Endoberfläche (30) und dem Schließelement (8) eingespannt ist.

16. System nach Anspruch 15, wobei in der Querschnittansicht die Oberseite des Brückenabschnitts (48) zentral relativ zu der ringförmigen Endoberfläche (30) angeordnet ist, um zuerst einen mittleren Abschnitt der ringförmigen Endoberfläche (30) zu berühren, wenn der Dichtungsringabschnitt (28) zwischen der ringförmigen Endoberfläche (30) und dem Schließelement (8) eingespannt ist.

17. System nach einem der Ansprüche 14 bis 16, wobei die Kapsel (2) eine Kapsel nach einem der Ansprüche 2 bis 13 ist.

18. Verwendung einer Kapsel (2) nach einem der Ansprüche 1 bis 13 in einer Getränkezubereitungsvorrichtung, die ein Umschließungselement (6) zur Aufnahme der Kapsel (2) umfasst, wobei das Umschließungselement (6) Fluideinspritzmittel umfasst, die unter Druck stehendes Fluid in die Kapsel (2) zuführen, wobei die Getränkezubereitungsvorrichtung ferner ein Schließelement (8) umfasst, wie beispielsweise eine Extraktionsplatte, die das Umschließungselement (6) der Getränkezubereitungsvorrichtung schließt, wobei das Umschließungselement (6) ein ringförmiges Ende mit einer ringförmigen Endoberfläche (30) aufweist, wobei die ringförmige Endoberfläche (30) wahlweise mit einer Vielzahl von radial verlaufenden offenen Nuten (40) versehen ist, wobei die Kapsel (2) im Umschließungselement (6) der Getränkezubereitungsvorrichtung positioniert ist, das Umschließungselement (6) mittels des Schließelements (8) der Getränkezubereitungsvorrichtung geschlossen wird und zumindest ein Abschnitt der Dichtungsstruktur zwischen dem Umschließungselement (6) und dem Schließelement (8) der Getränkezubereitungsvorrichtung eingespannt ist, wodurch die Dichtungsstruktur in dichtenden Kontakt mit der ringförmigen Endoberfläche (30) gebracht wird.

19. Verfahren zur Herstellung eines Kapselkörpers (2) einer Kapsel nach einem der Ansprüche 3 bis 5, ausgehend von einem halbfertigen tiefgezogenen Schalenelement, wobei das Verfahren das Reduzieren einer Wanddicke eines Abschnitts des Flansches (20) zum Bilden des Abschnitts der Oberseite des Brückenabschnitts (48) mit einer reduzierten Wanddicke umfasst, die kleiner als eine Wanddicke des Innen- und Außenwandabschnitts (46, 47) ist, wobei die Beschichtung von dem Abschnitt des Flansches entfernt wird, dessen Wanddicke vor oder während des Reduzierens der Wanddicke reduziert werden soll.

Revendications

1. Capsule (2) contenant une substance pour la préparation d'une boisson potable par extraction et/ou dissolution de la substance par apport d'un fluide sous pression dans la capsule, ladite capsule comprenant :

un corps de capsule (12) en aluminium ayant un axe central de corps de capsule (12A), ledit corps de capsule (12) en aluminium comprenant un fond (18), une paroi latérale (16), un rebord (20) s'étendant vers l'extérieur et une structure d'étanchéité au niveau dudit rebord (20) ; et
une feuille de couverture (14) fixée au dit rebord (20) et fermant hermétiquement la capsule (2) ;
dans laquelle ladite structure d'étanchéité est déformable pour fournir un contact étanche aux fluides avec une surface d'extrémité annulaire

(30) d'un élément d'enveloppement (6) d'un dispositif de préparation de boisson si la capsule est positionnée dans ledit élément d'enveloppement (6) et que ledit élément d'enveloppement (6) est fermé au moyen d'un élément de fermeture (8) du dispositif de préparation de boisson, tel qu'une plaque d'extraction du dispositif de préparation de boisson, au moins des parties dudit rebord (20) et ladite structure d'étanchéité étant serrées entre ladite surface d'extrémité annulaire (30) et ledit élément de fermeture (8), ladite surface d'extrémité annulaire (30) étant éventuellement dotée d'une pluralité de rainures ouvertes s'étendant radialement (40) ;
dans laquelle ladite structure d'étanchéité comprend une partie d'anneau d'étanchéité déformable (28) dudit rebord (20), ladite partie d'anneau d'étanchéité (28) faisant saillie axialement à partir de parties de base (44, 45) dudit rebord (20), auxquelles ladite feuille de couverture (14) est fixée, sur un côté des dites parties de base (44, 45) opposé à ladite feuille de couverture (14), ladite partie d'anneau d'étanchéité déformable (28) comprenant :

une partie de paroi interne (46) s'étendant depuis, et contiguë à, une partie de base interne (44) dudit rebord (20) ;
une partie de paroi externe (47) s'étendant depuis, et contiguë à, une partie de base externe (45) dudit rebord (20), ladite partie de paroi externe (47) étant située radialement vers l'extérieur et espacée radialement de ladite partie de paroi interne (46) ; et
une partie de pont (48) interconnectant ladite partie de paroi interne (46) et ladite partie de paroi externe (47), ladite partie de pont (48) étant située axialement espacée des dites parties de base (44, 45) dudit rebord (20) ;

dans laquelle, dans une vue en coupe transversale radiale, une partie supérieure de ladite partie de pont (48) axialement la plus éloignée des dites parties de base (44, 45) de rebord (20) est incurvée avec un rayon de courbure supérieur à deux fois une épaisseur de paroi de ladite partie supérieure de ladite partie de pont (48) ; et
dans laquelle ladite partie de paroi externe (47) s'étend selon un angle oblique par rapport à un plan de la partie de base contiguë associée (45) du rebord (20) et ladite partie de paroi interne (46) s'étend à partir de la partie de base contiguë associée (44) du rebord (20) selon un angle plus prononcé ou opposé par rapport à un plan de la partie de base contiguë associé du rebord (20) ;
caractérisée en ce que, dans une vue en coupe transversale, au moins une partie de ladite partie de paroi interne (46) est incurvée et ladite partie incurvée de ladite partie de paroi interne (46) est contiguë à la courbure de ladite partie supérieure de ladite partie de pont (48).

2. Capsule selon la revendication 1, dans laquelle au moins une partie de la partie supérieure de ladite partie de pont (48) a une épaisseur de paroi réduite inférieure à une épaisseur de paroi des dites parties de paroi interne et externe (47, 48).

3. Capsule selon la revendication 2, comprenant en outre un revêtement sur au moins un côté dudit corps de capsule (12), ledit revêtement étant absent dans au moins ladite partie de la partie supérieure de ladite partie de pont (48) ayant une épaisseur de paroi réduite.

4. Capsule selon la revendication 3, dans laquelle ladite partie non revêtue de ladite partie de pont (48) est sur un côté dudit rebord (20) opposé à ladite feuille de couverture (14) et a une surface texturée.

5. Capsule selon la revendication 4, dans laquelle ladite surface texturée comprend des crêtes et des vallées qui s'étendent dans le sens circonférentiel dudit rebord (20).

6. Capsule selon l'une quelconque des revendications précédentes, dans laquelle ladite partie de paroi externe (47) s'étend selon un angle oblique de 20 à 60° par rapport à un plan de la partie de base contiguë associée (45) du rebord (20) et ladite partie de paroi interne (46) s'étend à partir de la partie de base contiguë associée (44) du rebord (20) selon un angle de 60 à 160° par rapport audit plan de la partie de base contiguë associée du rebord (20).

7. Capsule selon l'une quelconque des revendications précédentes, dans laquelle, dans une vue en coupe transversale, au moins une partie de ladite partie de paroi externe (47) a un plan central incurvé.

8. Capsule selon la revendication 7, dans laquelle ladite partie incurvée de ladite au moins une des dites parties de paroi interne et externe (46, 47) est contiguë à la courbure de la partie supérieure de ladite partie de pont (48).

9. Capsule selon la revendication 8, dans laquelle, dans une vue en coupe transversale, ladite partie d'anneau d'étanchéité déformable (28) est en forme de Q.

10. Capsule selon l'une quelconque des revendications précédentes, comprenant en outre un élément de support entre lesdites parties de paroi interne et ex-

terne (46, 47).

11. Capsule selon l'une quelconque des revendications précédentes, dans laquelle ladite partie supérieure de ladite partie de pont (48) est positionnée pour être mise en contact d'abord par ladite partie d'extrémité annulaire (30), lorsque ladite partie d'anneau d'étanchéité (28) est serrée entre ladite surface d'extrémité annulaire (30) et ledit élément de fermeture (8) d'un dispositif de préparation de boisson compatible.

12. Capsule selon la revendication 11, dans laquelle ladite partie supérieure de ladite partie de pont (48) forme une crête s'étendant de manière circonférentielle autour de la ligne centrale de la capsule (2), ladite crête ayant un diamètre de 29 à 33 mm, plus préférablement de 30,0 à 31,4 mm et de préférence de 30,3 à 31,0 mm.

13. Capsule selon l'une quelconque des revendications précédentes, dans laquelle la partie d'anneau d'étanchéité (28) et le reste du corps de capsule (12) sont constitués du même matériau de plaque.

14. Système pour la préparation d'une boisson potable à partir d'une capsule (2) en utilisant un fluide alimenté sous pression dans la capsule (2), comprenant :

un dispositif de préparation de boisson comprenant un élément d'enveloppement (6) pour recevoir la capsule (2), dans lequel l'élément d'enveloppement (6) comprend un moyen d'injection de fluide destiné à alimenter un fluide sous pression dans la capsule (2), dans lequel le dispositif de préparation de boisson comprend en outre un élément de fermeture (8), tel qu'une plaque d'extraction, pour fermer l'élément d'enveloppement (6) du dispositif de préparation de boisson, dans lequel ledit élément d'enveloppement (6) a une extrémité annulaire (30) avec une surface d'extrémité annulaire, ladite surface d'extrémité annulaire (30) étant éventuellement pourvue d'une pluralité de rainures ouvertes s'étendant radialement (40) ;
une capsule (2) contenant une substance pour la préparation d'une boisson potable par extraction et/ou dissolution de la substance en fournissant un fluide sous pression dans la capsule (2), ladite capsule (2) comprenant :

un corps de capsule (12) en aluminium ayant un axe central de corps de capsule (12A), ledit corps de capsule (12) en aluminium comprenant un fond (18), une paroi latérale (16), un rebord (20) s'étendant vers l'extérieur et une structure d'étanchéité au niveau dudit rebord (20) ; et

une feuille de couverture (14) fixée audit rebord (20) et fermant hermétiquement la capsule (2) ;

dans lequel ladite structure d'étanchéité est déformable et en contact étanche aux fluides avec ladite surface d'extrémité annulaire (30) si la capsule (2) est positionnée dans ledit élément d'enveloppement (6) et que ledit élément d'enveloppement (6) est fermé au moyen dudit élément de fermeture (8), au moins des parties dudit rebord (20) et ladite structure d'étanchéité étant serrées entre ladite surface d'extrémité annulaire (30) et ledit élément de fermeture (8) ;
dans lequel ladite structure d'étanchéité comprend une partie d'anneau d'étanchéité déformable (28) dudit rebord (20), ladite partie d'anneau d'étanchéité (28) faisant saillie axialement à partir des parties de base (44, 45) dudit rebord (20), auxquelles ladite feuille de couverture (14) est fixée, sur un côté des dites parties de base (44, 45) faisant face audit élément d'enveloppement lorsque ladite capsule (2) se trouve dans ledit élément d'enveloppement (6), ladite partie d'anneau d'étanchéité déformable (28) comprenant :

une partie de paroi interne (46) s'étendant depuis, et contiguë à, une partie de base interne (44) dudit rebord (20) ;
une partie de paroi externe (47) s'étendant depuis, et contiguë à, une partie de base externe (45) dudit rebord (20), ladite partie de paroi externe (47) étant située radialement vers l'extérieur et espacée radialement de ladite partie de paroi interne (46) ; et
une partie de pont (48) interconnectant ladite partie de paroi interne (46) et ladite partie de paroi externe (47), ladite partie de pont (48) étant située axialement espacée des dites parties de base (44, 45) dudit rebord (20) ;

dans lequel, dans une vue en coupe transversale radiale, une partie supérieure de ladite partie de pont (48) axialement la plus éloignée des dites parties de base (44, 45) de rebord (20) est plate ou a un plan central incurvé avec un rayon de courbure supérieur à deux fois une épaisseur de paroi de ladite partie supérieure de ladite partie de pont (48) ; et
dans laquelle ladite partie de paroi externe (47) s'étend selon un angle oblique par rapport à un plan de la partie de base contiguë associée (45) du rebord (20) et ladite partie de paroi interne (46) s'étend à partir de la partie de base contiguë associée (44) du rebord (20) selon un angle plus

prononcé ou opposé par rapport à un plan de la partie de base contiguë associé du rebord (20) ; **caractérisé en ce que,** dans une vue en coupe transversale, au moins une partie de ladite partie de paroi interne (46) a un plan central incurvé.

15. Système selon la revendication 14, dans lequel ladite surface d'extrémité annulaire (30) est positionnée pour entrer d'abord en contact avec ladite partie supérieure de ladite partie de pont (48) lorsque ladite partie d'anneau d'étanchéité (28) est serrée entre ladite surface d'extrémité annulaire (30) et ledit élément de fermeture (8).

16. Système selon la revendication 15, dans lequel, dans une vue en coupe transversale, ladite partie supérieure de ladite partie de pont (48) est située au centre par rapport à ladite surface d'extrémité annulaire (30) pour entrer d'abord en contact avec une partie centrale de ladite surface d'extrémité annulaire (30) lorsque ladite partie d'anneau d'étanchéité (28) est serrée entre ladite surface d'extrémité annulaire (30) et ledit élément de fermeture (8).

17. Système selon l'une quelconque des revendications 14 à 16, dans lequel la capsule (2) est une capsule selon l'une quelconque des revendications 2 à 13.

18. Utilisation d'une capsule (2) selon l'une quelconque des revendications 1 à 13 dans un dispositif de préparation de boisson comprenant un élément d'enveloppement (6) pour recevoir la capsule (2), dans laquelle l'élément d'enveloppement (6) comprend un moyen d'injection de fluide fournissant un fluide sous pression dans la capsule (2), dans laquelle le dispositif de préparation de boisson comprend en outre un élément de fermeture (8), telle qu'une plaque d'extraction, fermant l'élément d'enveloppement (6) du dispositif de préparation de boisson, dans laquelle ledit élément d'enveloppement (6) a une extrémité annulaire avec une surface d'extrémité annulaire (30), ladite surface d'extrémité annulaire (30) étant éventuellement dotée d'une pluralité de rainures ouvertes s'étendant radialement (40), dans laquelle la capsule (2) est positionnée dans l'élément d'enveloppement (6) du dispositif de préparation de boisson, l'élément d'enveloppement (6) est fermé au moyen de l'élément de fermeture (8) du dispositif de préparation de boisson et au moins une partie de la structure d'étanchéité est serrée entre l'élément d'enveloppement (6) et l'élément de fermeture (8) du dispositif de préparation de boisson, amenant la structure d'étanchéité à entrer en contact d'étanchéité avec la surface d'extrémité annulaire (30).

19. Procédé de fabrication d'un corps de capsule (2) d'une capsule selon l'une quelconque des revendications 3 à 5, à partir d'un élément de coupelle embouti semi-fini, le procédé comprenant la réduction d'une épaisseur de paroi d'une partie dudit rebord (20) pour former ladite partie de ladite partie supérieure de ladite partie de pont (48) ayant une épaisseur de paroi réduite inférieure à une épaisseur de paroi des dites parties de paroi interne et externe (46, 47), dans lequel ledit revêtement est retiré de ladite partie dudit rebord dont l'épaisseur de paroi doit être réduite avant ou pendant la réduction de l'épaisseur de paroi.

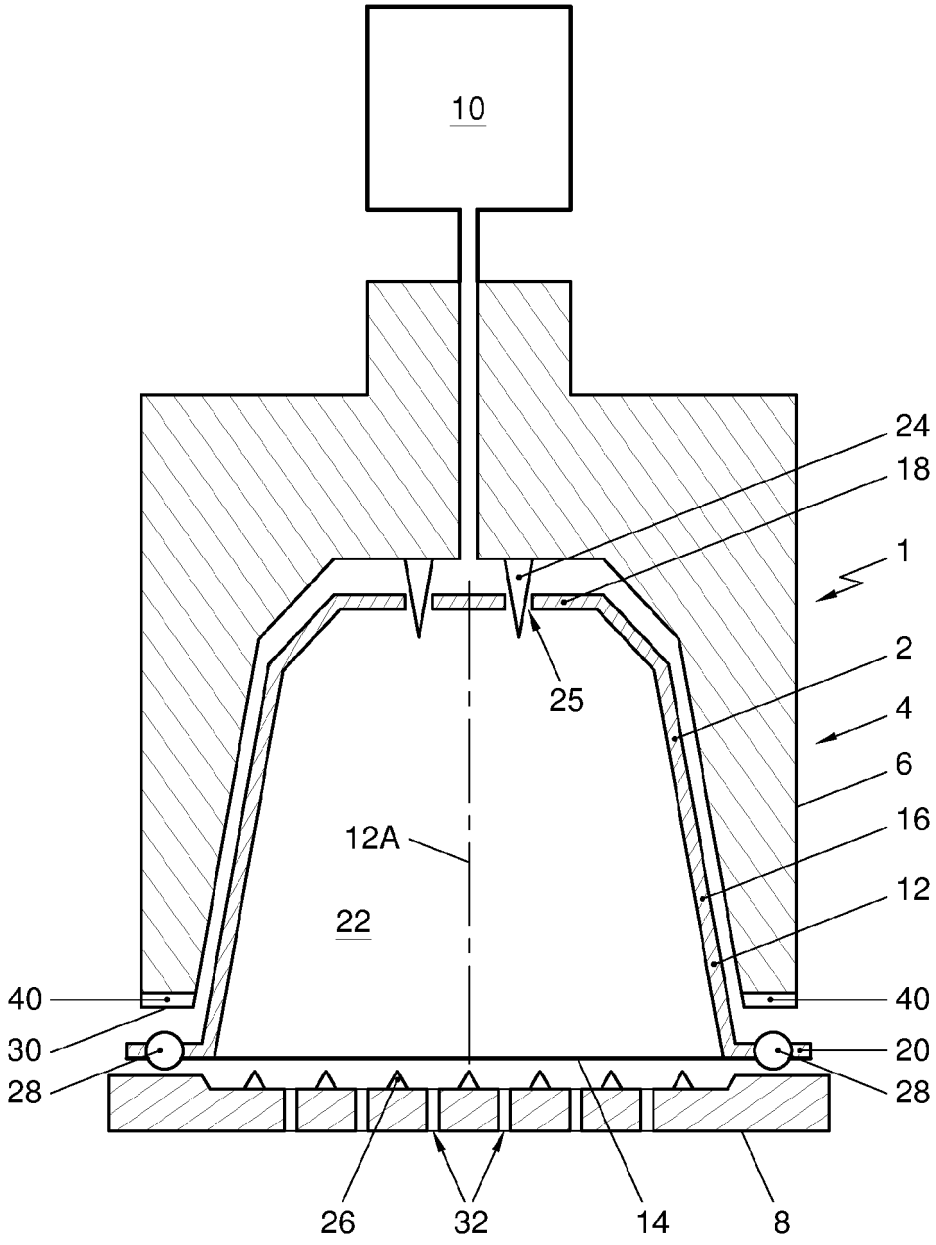


Fig. 1

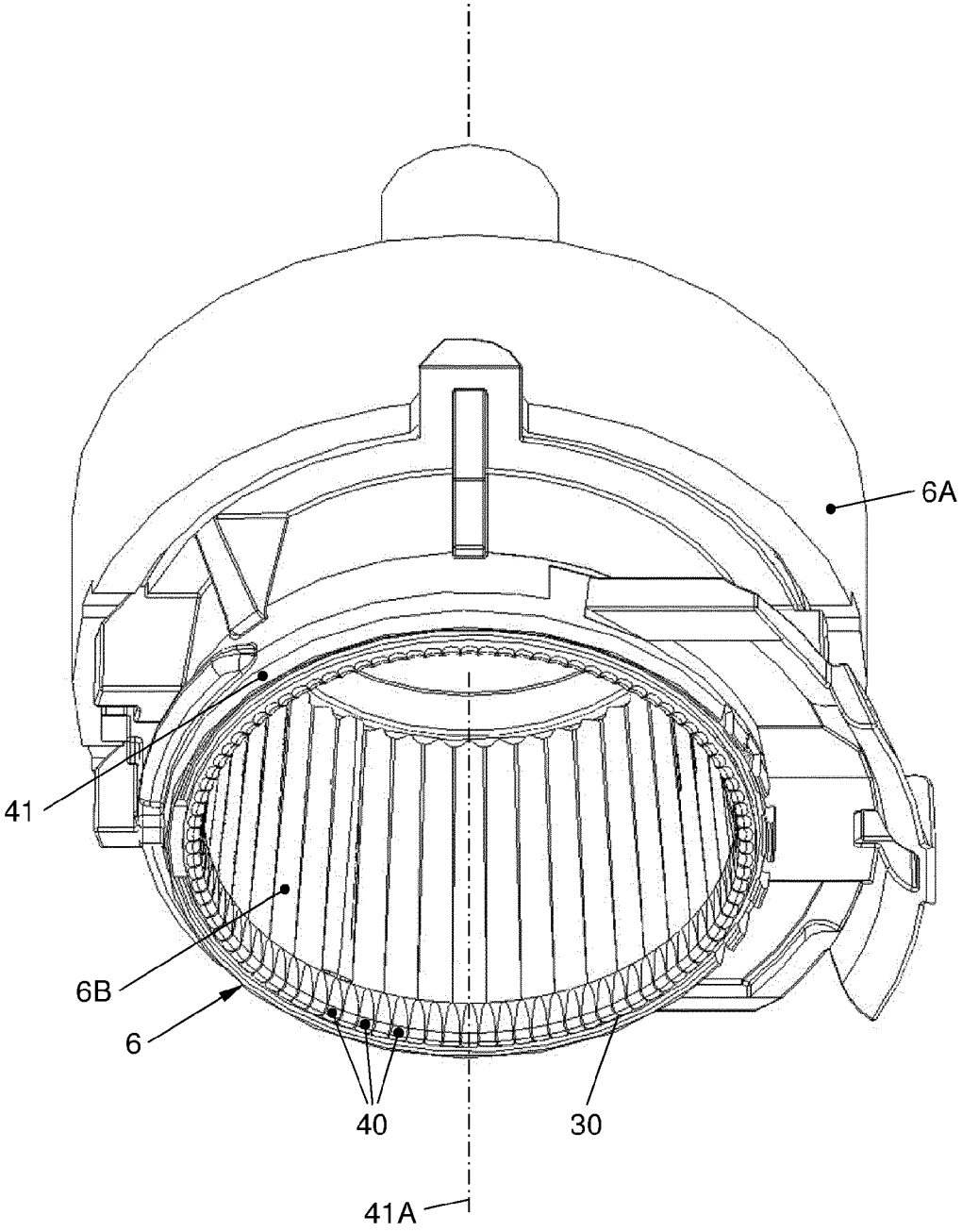
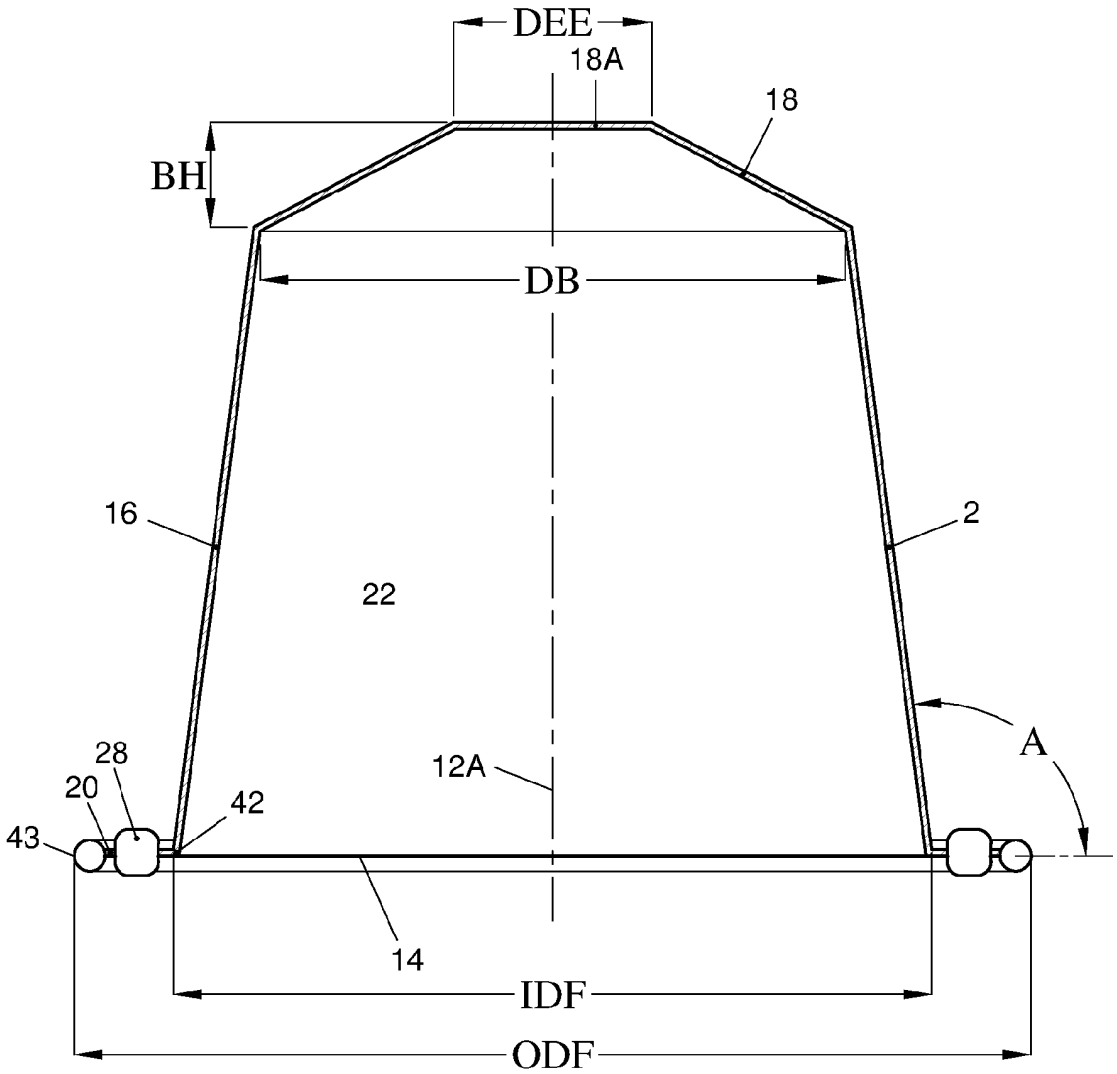


Fig. 2


DEE
18A
18
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12A
43
14
IDF
ODF

Fig. 3A

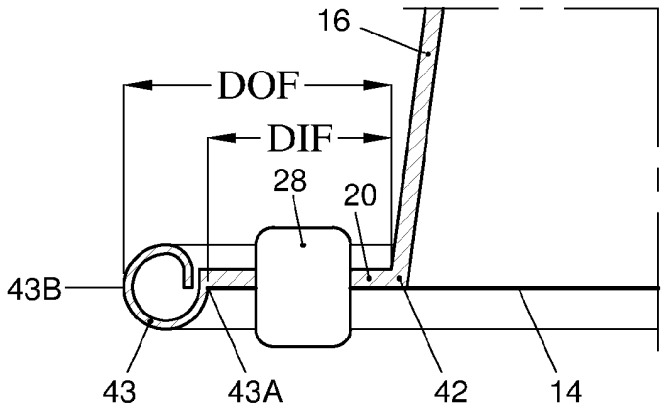
16
DOF
DIF
28
20
43B
43
43A
42
14

Fig. 3B

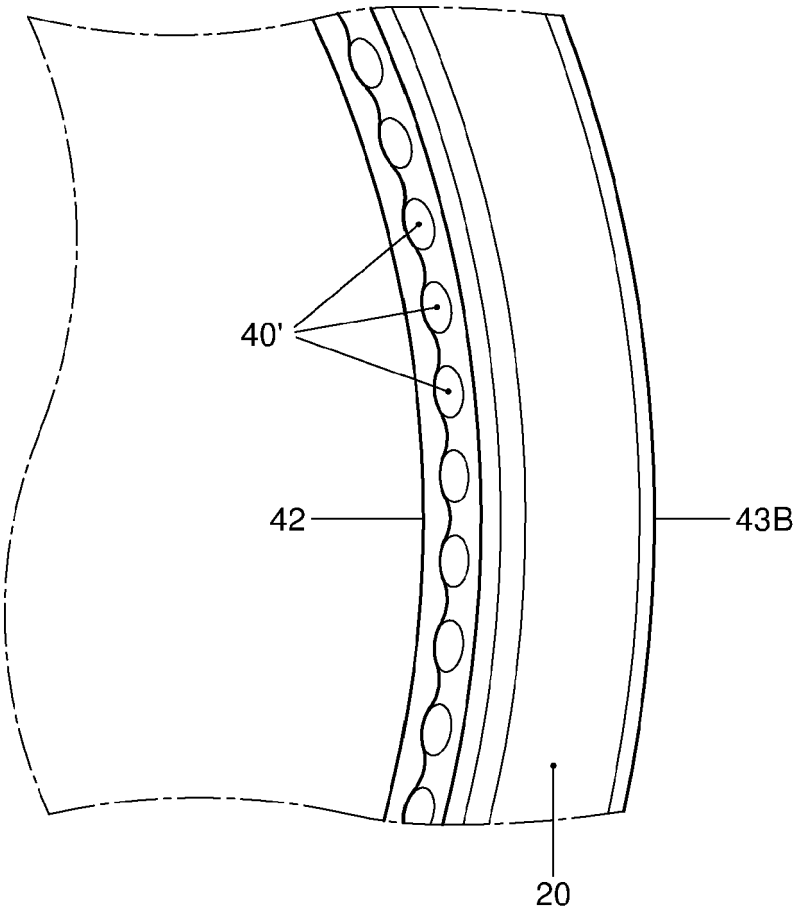

Fig. 3C

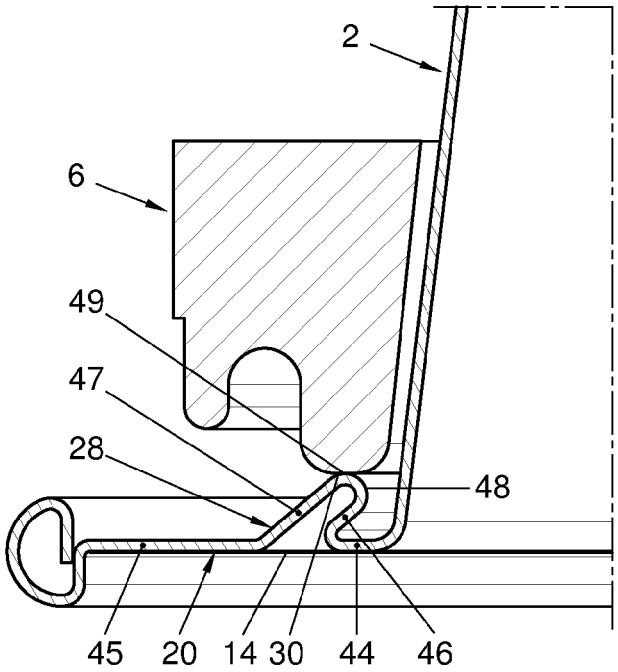

Fig. 4A

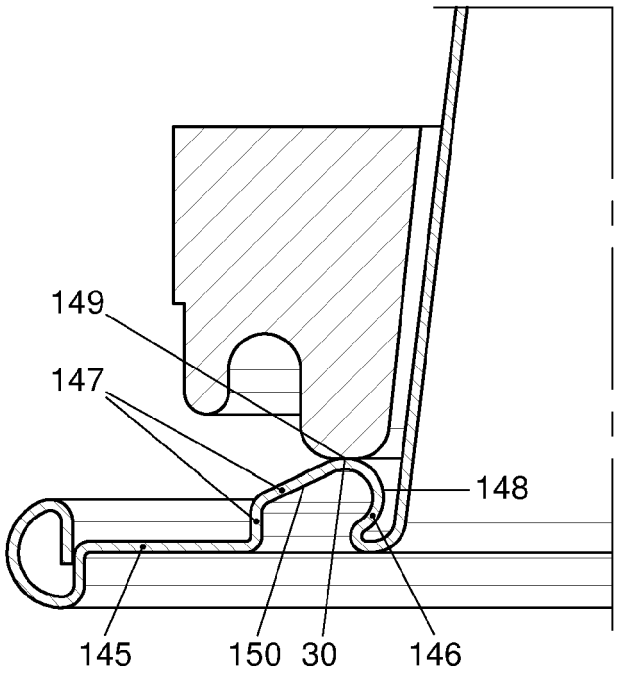

Fig. 4B

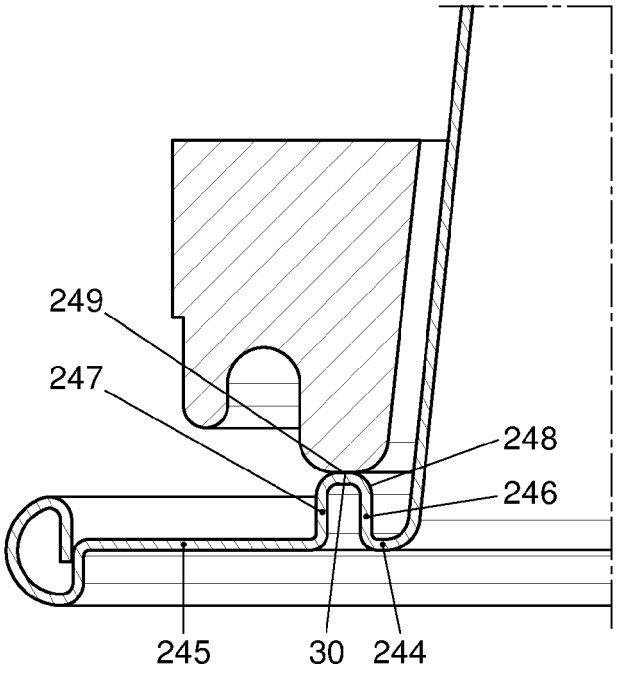

Fig. 4C

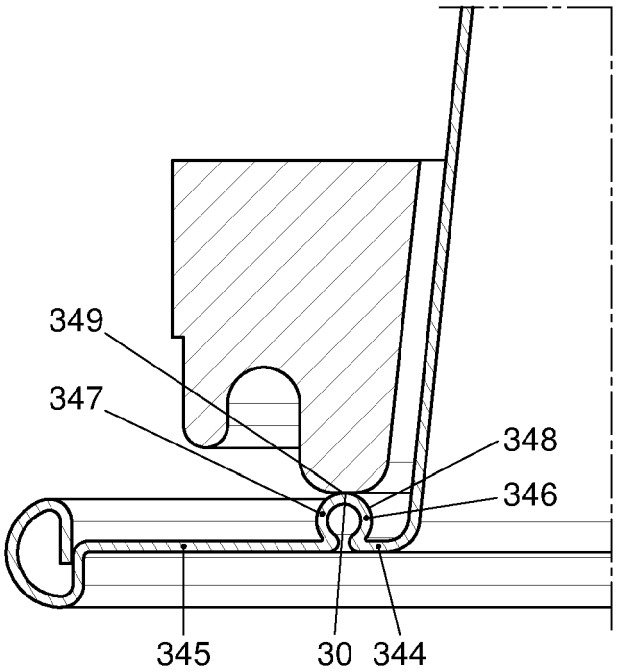

Fig. 4D

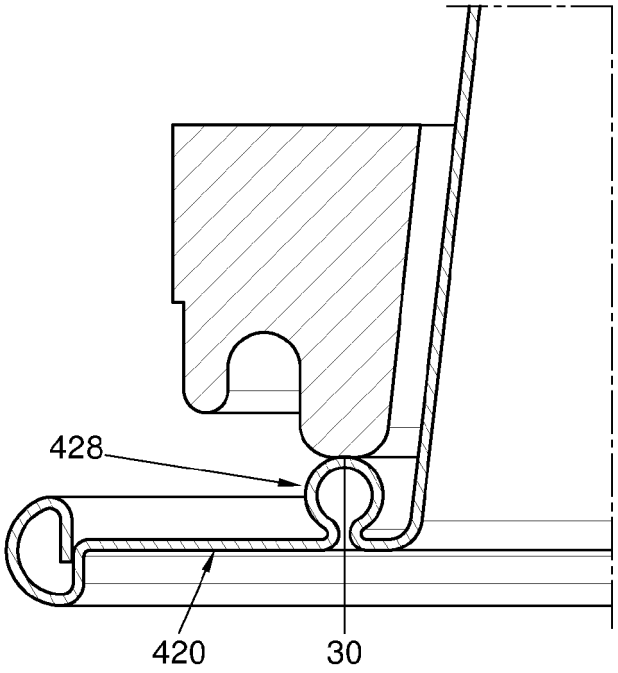

Fig. 4E

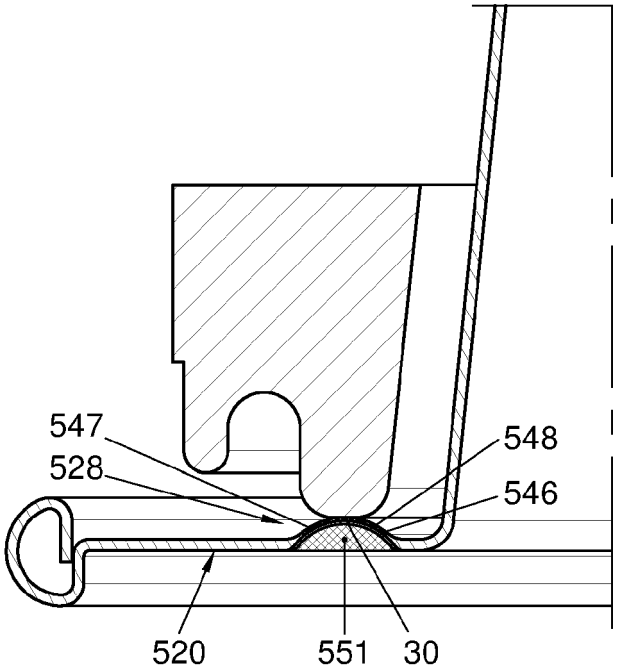

Fig. 4F

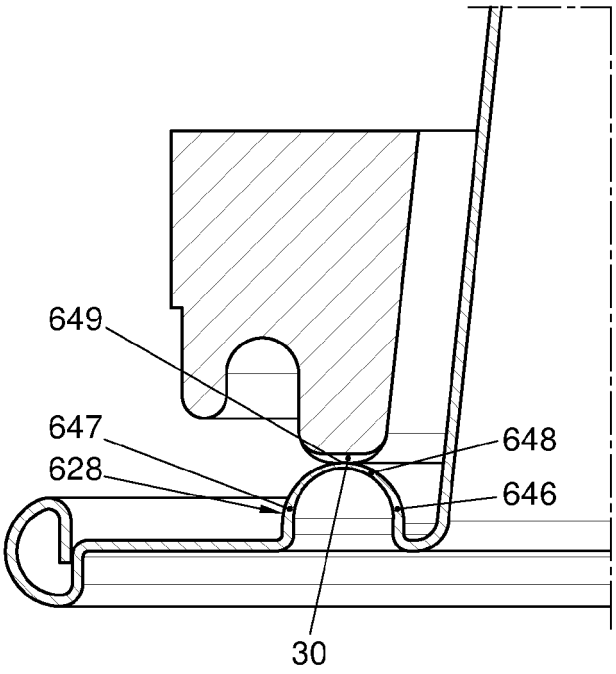

Fig. 4G

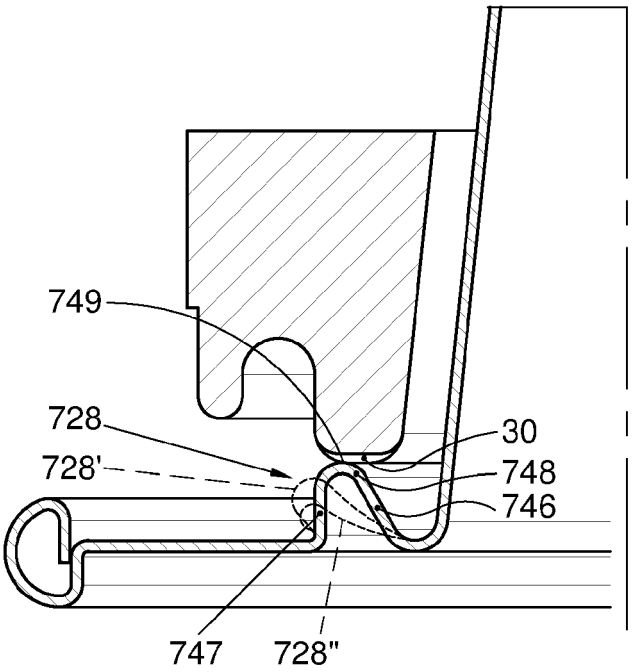

Fig. 4H

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- WO 2014184653 A1 **[0002]**
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