(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 July 2017 (13.07.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/117648 A1

(51) International Patent Classification:
B65D 41/00 (2006.01)

(21) International Application Number:
PCT/CA2016/051330

(22) International Filing Date:
16 November 2016 (16.11.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/274,404 4 January 2016 (04.01.2016) US

(71) Applicant: **HUSKY INJECTION MOLDING SYSTEMS LTD.** [CA/CA]; 500 Queen Street South, Bolton, Ontario L7E 5S5 (CA).

(72) Inventors: **NIEWELS, Joachim Johannes**; 7155 9th Line, R. R. #3, Thornton, Ontario L0L 2N0 (CA). **HYVARINEN, Heikki Sakari**; 4226 Rockwood Road, Mississauga L4W 1L7 (CA).

(74) Agent: **GOW, Geoffrey**; c/o Husky Injection Molding Systems Ltd., 500 Queen Street South, Bolton, Ontario L7E 5S5 (CA).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

(54) Title: CONTAINERS AND CLOSURES

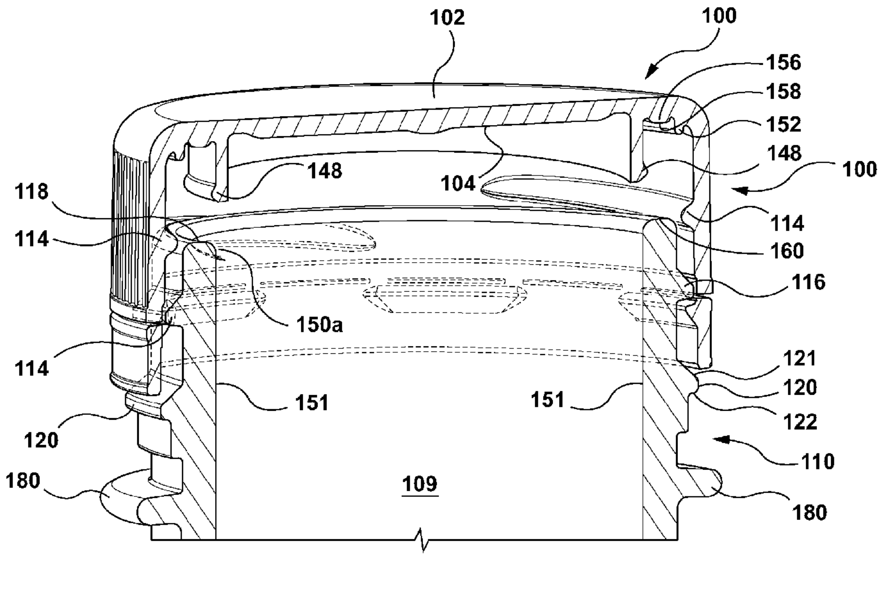


FIG. 2

(57) Abstract: A container apparatus has a first part, and a second part for releasably closing an opening in the first part. A contact interface is provided between a contact surface of the first part and a contact surface of the second part. The contact surfaces comprise co-operating micro-surface structures operable such that a first force is required to induce relative movement between the contact surfaces in a first direction that is substantially larger than a second force required to induce relative movement in a second direction opposite the first direction. The parts may be a container a closure. The contact surfaces may comprise respective co-operating top contact surfaces and/or co-operating contact surfaces of threads.

WO 2017/117648 A1

CONTAINERS AND CLOSURES

TECHNICAL FIELD

This relates to closures and containers.

BACKGROUND

Containers of various types are known for liquids, gases and/or solids. Also, various types of closures for containers are known.

Containers, including containers blown from preforms, may be made from a variety of materials including glass, metals and polymers/plastics. Many containers are configured in the form of a bottle and many are made from a wide variety of materials including polymers/plastics such as for example polyethylene terephthalate ("PET"). Similarly closures for such containers may also be made from a wide variety of materials including polypropylene and polyethylene.

Closures may be secured to containers in a variety of ways, including by screwing the closure onto the container using mating threads on the outside of the neck portion of the container and the inside sidewall surface of the closure.

Consequently, variability in the coefficients of friction, and thus the resultant friction forces, during closing and opening results in considerable variability in the torque required during opening.

Variability in the opening and closing coefficients of friction might be due to environmental factors such temperature, lubrication, e.g. moisture, and sticking due to contaminants, e.g. sugar build up from container contents. Variability in the coefficients of friction might also be due to different materials having different friction behavior that does not follow the Coulomb Friction Model, varying velocity and contact pressure between the sliding surfaces of the closure and the neck portion of the container, creep of the contact surfaces of the closure and/or the neck portion of the container, and macro and micro form locking.

As such, in at least some situations, the torque required to remove the closure may not be controlled to the desired accuracy. Thus, the consumer experience may be adversely impacted, either due to the closure being too hard to open or due to the closure being too easy to open, thereby causing leakage.

SUMMARY

According to one aspect there is provided a container apparatus comprising a combination of a first part and a second part for releasably closing an opening in said the first part. The apparatus comprises: a contact interface between a contact surface of the first part and a contact surface of the second part. The contact surfaces comprise co-operating micro-surface structures operable such that a first force is required to induce relative movement between the contact surfaces in a first direction that is substantially larger than a second force required to induce relative movement in a second direction opposite the first direction. The first part may be a container and said second part may be a closure. The contact surfaces may comprise respective co-operating top contact surfaces of the container and the closure. The contact surfaces may also or alternatively comprise respective co-operating contact surfaces of threads of the container and the closure.

According to another aspect there is provided a method of manufacturing a container apparatus as recited above, comprising: (a) forming the first part; and (b) applying the micro-surface structures to the contact surface of the first part. The method may also comprise: (c) forming the second part; and (d) applying micro-surface structures to the contact surface of the second part. Steps (a) and (b) may be performed together and may be done in a molding machine. Steps (c) and (c) may be also or alternately be performed together and may be done in a molding machine. .In other embodiments, the micro-surface structures are applied to the first part after step (a). In other embodiments, the micro-surface structures be also or alternatively be applied to the second part after step (c).

According to another aspect there is provided a first part of a container apparatus for use with a second part of a container apparatus. The second part is configured for releasably closing an opening in the first part. The first part comprises: a contact surface operable to engage with a contact surface of the second part at a contact interface. The contact surfaces comprise co-operating micro-surface structures operable such that when said contact surface of the first part is engaged with said contact surface of the second part, a first force is required to induce relative movement between the contact surfaces in a first direction that is substantially larger than a second force required to induce relative movement in a second direction opposite the first direction.

According to another aspect there is provided a first part of a container apparatus for use with a second part of a container apparatus. The first part is for releasably closing an opening in the second part. The first part comprises: a contact surface operable to engage with a contact surface of the second part at a contact interface. The contact surfaces comprising co-operating micro-surface structures operable such that when the contact surface of the first part is engaged with the contact surface of the second part, a first force is required to induce relative movement between the contact surfaces in a first direction that is substantially larger than a second force required to induce relative movement in a second direction opposite the first direction.

According to another aspect there is provided a container apparatus comprising a container and a closure. The apparatus comprises: a contact interface between a contact surface of the container and a contact surface of the closure. The contact surfaces of the container and closure at the contact interface comprising co-operating micro-surface structures operable to provide a micro-locking force that resists relative movement between the contact surfaces in a direction to dis-engage the closure from the container, that is substantially greater than a friction force generated by other contact interfaces between other surfaces of the closures and other surfaces of the container that resists relative movement between the contact surfaces in a direction to dis-engage the closure from the container. The contact surfaces may be co-operating top contact surfaces of the container and closure. The contact surfaces may comprise respective co-operating sealing surfaces of the container and the closure.

Other features will become apparent from the drawings in conjunction with the following description.

DESCRIPTION OF THE DRAWINGS

In the figures which illustrate example embodiments,

FIGS. 1A and 1B are graphs illustrating the theoretical relationship between removal torque and the coefficient of friction present during application of a closure and between removal torque and the coefficient of friction present during removal of the closure, respectively;

FIG. 2 is a broken away, elevation section view of part of a closure and part of a container in a disengaged position relative to each other;

FIG. 3 is a broken away elevation section view of the closure and container of FIG. 2 with the closure and container at a commencement of pre-alignment position relative to each other;

FIG. 4 is a broken away elevation section view of the closure and container of FIG. 2 with the closure and container in a first seal engagement position relative to each other;

FIG. 5 is a broken away elevation section view of the closure and container of FIG. 2 with the closure and container in a final fully engaged and sealed position relative to each other;

FIG. 6 is a broken away elevation section view of a part of a closure and a part of a container showing the relative positions of the closure and the container at the beginning of capping;

FIG. 7 is a broken away elevation section view of the closure and container of FIG. 6 during capping;

FIG. 8 is a broken away elevation section view of the closure and container of FIG. 6 at the end of translation of the closure during capping and when finalizing capping;

FIG. 9 is a broken away elevation section view of the closure and container of FIG. 6 during opening;

FIG. 10 is a partial vertical elevation medial cross sectional view through a portion of the container of FIG. 6;

FIG. 11 is a partial vertical elevation medial cross sectional view through a portion of the closure of FIG. 6;

FIG. 12 is a partial vertical elevation medial cross sectional view through portions of the closure and container of FIG. 6 at the end of translation of the closure during capping;

FIG. 13 is a perspective view of a flip-top type closure with complementary spud and opening;

FIG. 14 is a front perspective view of a portion of the top of a bottle and a plug type closure in a disengaged position relative to each other;

FIGS. 15A to 15F are schematic views of a closure and container showing the sequential engagement of threads from a disengaged position to a fully engaged position;

FIG. 16 is a schematic view showing relative positions of micro-surface structures during relative movement of two contact surfaces;

FIG. 17A is a schematic view showing interaction of micro-surface structures between top contact surfaces;

FIG. 17B is an example plot of a relationship between removal torque and thread lead;

FIGS. 17C is a schematic view showing interaction of micro-surface structures between threads;

FIG. 18 is a schematic view showing interaction of micro-surface structures during relative vertical movement of two contact surfaces;

FIG. 19 is a perspective view of a portion of a container showing possible locations of micro-surface structures;

FIG. 20 is a perspective sectional view of a part of a closure showing possible locations of micro-surface structures;

FIGS. 21A to 21F are perspective and elevation cross sectional schematic views of micro-surface structures; and

FIG. 22 is a schematic view of an injection molding system that may be employed to form any of the closures and containers depicted in FIGS. 2 to 13, and 14, 19 and 20.

DETAILED DESCRIPTION

By way of introduction, it is noted that the coefficient of friction between the contact surfaces of a closure, such as closure 100 (FIG. 2), and the neck portion of a corresponding container, such as container 110 (FIG. 2), during application of the closure onto the container is a strong factor in the amount of torque required to close the container using the closure and, thus, the amount of torque require to subsequently open the container when removing the closure (also referred to as the removal torque). FIG. 1A is a plot of the theoretical influence of the coefficient of friction present during application of the closure onto the container ("COFclose"), on the removal torque. The solid-line portion of the plot shows the typical range of the COFclose¬, namely approximately 0.14 to approximately 0.28, and the dotted-line portion of the plot shows the extrapolated values of the removal torque that can be expected with a lower COFclose.

Additionally, the coefficient of friction between the contact surfaces of a closure, such as closure 100, and the neck portion of a container, such as container 110, during removal of the closure from the container ("COFopen"), which may be different than the coefficient of friction during application/closing) is also a strong factor in the amount of torque required to open the container by removing the closure from the container. FIG. 1B is a plot of the theoretical influence of the coefficient of friction associated with removal/opening - COFopen - on the removal torque. Again, the solid-line portion of the plot shows the typical range of the COFopen¬, namely approximately 0.14 to approximately 0.28, and the dotted-line portion of the plot shows the extrapolated values of the removal torque that can be expected with a lower COFopen.

With reference now to FIG. 2, an example of a container apparatus is shown that includes a closure 100 and container 110. In overview, engineered, micro-surface structures (sometime referred to interchangeably as micro-surface textures or micro-surface features) such as those described hereinafter, may be applied to co-operating, interfacing surface areas of a closure, such as closure 100, and a corresponding engageable container, such as container 110, to provide for pre-determined and/or predictable removal torque characteristics associated with the disengagement/removal of closure 100 from container 110. In some embodiments, the co-operating, interfacing micro-surface structures provide for relatively easy movement of a surface of container 100 relative to a surface of closure 110 (eg. the features may provide for an “easy-gliding” functionality of one surface relative to the other in at least one direction of relative movement). In other embodiments, the co-operating micro-surface features provide for “micro-locking” functionality whereby the features provide for a predictable, relatively high degree of resistance of movement of a surface of container 100 relative to a surface of closure 110 in one relative direction. Such features may, in some embodiments, act as a master control over the opening torque required to move closure 100 relative to container 110 when disengaging/removing closure 100 from engagement with container 110. By providing for engineered, micro-surface structures on co-operating interfacing surfaces of a closure 100 and a container 110 the effective friction force is increased at the desired surfaces, and/or the friction force is substantially reduced or virtually eliminated at other desired surfaces, resulting in a situation where the effect of hard-to-control friction coefficient dependent effects is overwhelmed by engineered effects.

Closure 100 may be made from any suitable material(s) capable of providing micro-surface features such as a resilient plastic/polymer, such as by way of example only, resilient polypropylene (PP) or high density polyethylene (HDPE). Also shown is an example neck region 112 defining part of an inner cavity 109 of an example container 110. Container 110 may also be made entirely from any suitable material(s) capable of providing micro-surface features, such as, by way of example only, polyethylene terephthalate (PET) or polypropylene or polyethylene.

Container 110 may be a container blown from a preform. Both container 110 and closure 100 may be formed, at least in part, using adapted injection molding equipment, such as for example injection molding equipment of the type generally known to persons skilled in the art in the industry, and typically additional equipment capable of applying micro-surface features to the container and closure after they have been initially formed using the injection molding equipment. In some embodiments, the micro-surface structures on the container 110 and/or closure 100 may be created using modified molding surfaces in known types of injection molding machines or other molding machines. For example, such modified molding surfaces may be created by known techniques such as by way of example only, laser ablation or discharge machining of the molding surface in a molding machine. Alternatively, the micro-surface structures may be post-formed on previously formed surfaces of the closure 100 and/or container 110 by a variety of known types of processes/techniques such as by way of example only, laser cutting such as with computer controlled lasers, erosion and/or deposition techniques/processes .

The features of closure 100 and the features of container 110 as hereinafter described, including the micro-surface structures, may each be formed as unitary pieces of material. For example, multi-material molding processes/techniques may be employed such as co-injection or over-molding to form container 110 and closure 100.

Closure 100 may be configured in a generally right circular cylindrical tubular shaped shell 101 that is closed at a top end with a circular disc shaped top wall 102 with a downward facing, generally flat, surface 104. Shell 101 also has a generally right circular cylindrical tubular shaped side wall 106 having an outward facing, generally right circular cylindrical surface 103 and inward facing, generally right circular cylindrical surface 108. Outward facing surface 103 may be provided with a plurality of spaced vertically oriented ribs 105 (i.e. knurls) that may assist in application and removal of closure 100 to a container by a capping machine and/or an individual.

Inward facing surface 108 of closure 100 may be provided with one or more angled, spiral spaced threads or bayonets 114. Threads 114 formed on the inward facing surface 108 of closure 100 may complement and be configured to engage with corresponding one or more angled, spiral spaced threads 116 formed on an exterior generally cylindrical surface 117 of neck region 112 of container 110, proximate an upwardly oriented opening 119 into the inner cavity of container 110. By providing more than one set of complementary spaced threads 114 and 116, it may be possible to have more than one thread start engagement position.

Closure 100 may be secured to container 110 to close opening 119 by engaging threads 114 of closure 100 with threads 116 of container 110 and rotating threads 114 relative to threads 116. To effect such an engagement, respective threads 114, 116 should be initially positioned in a suitable thread start engagement position of closure 100 relative to container 100 initially by suitable angular positioning about axis X-X of threads 114 relative to threads 116 and with vertical / axial positioning of closure 100 relative to container 110, which may be achieved for example by moving closure 100 relative to container 110 through the positions shown in FIGS. 15A to 15C. The engagement of the threads 114 and 116 may provide a seal to seal any contents in the container 110 from the external environment. A suitable thread start engagement position of closure 100 relative to container 110 provides that the central axial axes of the container 110 and the closure 100 are aligned about common vertical/longitudinal axis X-X and includes both a suitable thread start angular orientation about axis X-X (FIG. 2) and a suitable thread start axial (eg. vertical/longitudinal) position of closure 100 relative to container 110 such as shown in FIG. 15C. When closure 100 and container 110 are positioned relative to each other at both a suitable thread start angular orientation and a suitable thread start axial / vertical position, the rotation of closure 100 in one rotational direction relative to container 110 will cause threads 114 to engage with threads 116. In such a thread start engagement position threads 114 of closure 100 are axially aligned, and are also angularly and axially positioned, with respect to threads 116 of container 110 so that threads 114 of closure 100 are capable of properly engaging with threads 116 of the container 110 when closure 100 is thereafter rotated relative to container 110 from the position shown in FIG. 15C about common vertical / longitudinal axis X-X as shown in FIG. 2, through the positions shown in FIG. 15D and then FIG. 15E to reach the fully engaged thread position shown in FIG. 15F.

The exterior surface 117 of neck region 112 of container 110 may also be provided with a pilfer band 120 in the form of a circumferential, generally toroidal shaped shoulder which has an upper, angled shoulder surface 121 and a generally horizontally oriented (ie. generally perpendicular to the orientation of the exterior surface 117) lower, shoulder surface 122. Neck region 112 may also have a support ledge 180 positioned beneath the pilfer band 120 in the form of a lower extended annular shoulder which may be used during blow molding, capping and handling of the container.

A generally right circular cylindrical tubular tamper evident band generally designated 125 may be located vertically / axially below side wall 103 of closure 100. Tamper evident band 125 may be connected by frangible connector portions 126 to generally right circular cylindrical tubular side wall 103. Tamper evident band 125 may also include a plurality of circumferentially extending, spaced cams 127 in the form of shoulder members formed on inner generally cylindrical surface 130 of tamper evident band 125. Cams 127 may be provided with a generally horizontally oriented upper shoulder surface 128 and a lower, angled shoulder surface 129. During application of closure 100 to container 110, by rotation about axis X-X in one rotational direction, tamper evident band 125 will elastically deform such that the angled surface 129 of tamper evident band cams 127 will slide over angled surface 121 of pilfer band 120 such that lower generally horizontal surface 122 of pilfer band 120 will be in face to face relation with the upper surfaces 128 of tamper evident band cams 127. When closure 100 is to be removed from neck region 112 of container 110, the resistance force created by the interface between lower generally horizontal surface 122 of pilfer band 120 that comes into engagement with the generally horizontally oriented upper surfaces 128 of tamper evident band cams 127 will be greater than the breaking force of frangible connector portions 126, and thus continued opposite direction rotation of closure 100 relative to container 110 about axis X-X will cause the frangible connector portions 126 to break. Thus, closure 100 can be removed from engagement with container 110, but tamper evident band 125 will remain in position on container 110.

In some embodiments, closure 100 may also have a plug seal device 140 having sealing features which, when closure 100 is applied to container 110, create a solid, fluid and/or gas seal between: (i) the interior cavity 109 of the container 110 and the contents that may be contained therein; and (ii) the external environment. Plug seal device 140 may also include a pre-alignment feature which may help facilitate the vertical / longitudinal axial movement and positioning of closure 100 relative to container 110 as it moves from the position shown in FIG. 15A through the start of a seal engagement position, to the thread start engagement position shown in FIG. 15C, and through to the final thread engagement position shown in FIG. 15F.

Returning to FIG. 2, a plug seal device such as plug seal device 140 may be integrally connected and formed with top wall 102 of closure 100 and may depend substantially vertically/axially downward therefrom. Plug seal device 140 can be spaced radially apart from inward facing surface 108 of side wall 106 of shell 101 to allow the upper portion 118 of neck region 112 of container 110 to be received there between.

Plug seal device 140 may have a generally right circular cylindrical tubular upper wall section 142 and a sealing section 148. Sealing section 148 may be integrally formed as part of plug seal device 140 and may be formed in a generally semi-circular toroidal shape, lobe shape, a generally annular ring shape or any other suitable shape that protrudes radially outward beyond both the radially outward facing cylindrical surface 144 of upper wall section 142. Sealing section 148 may have a generally arcuate outer sealing surface area.

If present, sealing section 148 may be configured and operable such that when it engages with inner surface 151 of the neck region 112 it may provide a complete circumferential seal between plug seal device 140 and the inner surface 151 of neck region 112 of container 110, when sealing section 148 is received through opening 119 of neck region 112 and sealing section 148 is engaged with the inner surface 151. In operation of some embodiments, when being received into opening 119 of neck region 112, sealing section 148 of plug seal device 140 may provide the first / initial seal between the inner cavity 109 of container 110 and the external environment. In some embodiments, additional seals may also be provided between the inner cavity 109 and the external environment, such as a seal between the plug seal device 140 and an external surface of the neck region 112 and the mating top contact surfaces of the closure 100 and container 110, as described further hereinafter.

In other embodiments, seal plug device 140 may not be present or may be shaped or configured differently than that shown in FIGS. 2 to 5. For instance, as shown in the embodiment of the closure shown in FIG. 6, a plug seal device 141 may have a sealing ring 143 with different geometric proportions than sealing section 148, such as the above-noted lobe shape.

An outer alignment circular/annular ring 152 may also be positioned radially outwardly from plug seal device 140 and inwardly from side wall 106, and may be integrally formed at and with a corner region that joins top wall 102 and side wall 106. Outer alignment ring 152 may operate in conjunction with the upper portion of upper section 142 of plug device 140 to assist with maintaining the generally parallel orientation of neck region 117 relative to plug seal device 140 and side wall 106 of closure 100 when closure 100 is fully engaged on neck region 112 of container 110.

A closure top sealing ring 156 may also be positioned radially outwardly from plug seal device 140 and radially inwardly from outer alignment ring 152, may be integrally connected and formed with top wall 102 of closure 100 and may depend substantially vertically/axially downward therefrom. Closure top sealing ring 156 may include a closure top contact surface 158, facing substantially vertically/axially downward and positioned on a distal end of closure top sealing ring 156 opposite downward facing surface 104. Closure top sealing ring 156 and closure top contact surface 158 may be configured so that when closure 100 is in a fully engaged position relative to container 110, as shown in FIGS. 5 and 8, closure top contact surface 158 contacts upward facing container top contact surface 160 located at the top of upper portion 118 of neck region 112 of container 110.

Referring now to FIGS. 6 to 10, the areas of contact between closure 100 and container 110 during application (also referred to as capping) and removal of closure 100 will be described. At the outset, it is noted that, during capping, closure 100 is typically rotated clockwise about a common axis X (FIG. 2) relative to container 110 by a capping machine, which is depicted schematically at reference numeral 200.

Capping machine 200 typically applies a substantially constant, predefined torque to closure 100 and typically for a predetermined amount of time to screw closure 100 onto neck portion 112 of container 110.

Due to the clockwise rotation of closure 100 (indicated with curved arrow and dotted, helical line) and engagement of threads 114 and 116, closure 100 is translated downward (indicated with vertical arrow facing down).

At the beginning of capping and during capping (FIGS. 6 and 7), at least a portion of thread tip blends 202 on the application faces 203 (FIG. 10) of threads 116 contact at least a portion of the thread root blends 204 on the application faces 205 (FIG. 10) of threads 114 and at least a portion of the thread crests 206 of threads 116 contact at least a portion of the thread roots 208 of threads 114.

At the end of the vertically/axially downward translation of the closure 100 (FIG. 8), in addition to the contact that exists during capping as described above, there also exists contact between closure top contact surface (TSS) 158 and container top contact surface (TSS) 160 and between outer alignment ring 152 (FIG. 5) and an upper ring 210 (FIG. 6) that extends annularly around upper portion 118 of neck region 112 and protrudes from cylindrical surface 117. If upper ring 210 is not present, as in the case of the embodiment shown in FIG 5, at the end of translation of closure 100, outer alignment ring 152 may contact upper portion 118 of neck region 112 directly.

At the end of translation of closure 100, when finalizing capping, further substantial vertical/axial downward translation of top wall 102 of the closure 100 is blocked by at least the abutment of closure top contact surface 158 with container top contact surface 160. Thus, additional rotation of closure 100 will result in a shift in contact from between thread tip blends 202 on application faces 203 of threads 116 and thread root blends 204 on application faces 205 of threads 114, to between thread tip blends 212 on pressure faces 213 (FIG. 10) of threads 116 and thread root blends 214 on pressure faces 215 (FIG. 10) on threads 114, as also seen in FIG. 12. Further rotation of closure 100 during finalizing capping also results in the lower portion of side wall 106 of closure 100 becoming elastically deformed in a generally vertical direction. The result of this strain and strain energy may be particularly located in the region of side wall 106 in the vicinity of top wall 102 and may create an increase in pressure at the contact interface between closure top contact surface 158 and container top contact surface 160 and an increase in pressure at the contact interface between the thread tip blends 212 on pressure faces 213 of threads 116 and thread root blends 214 on pressure faces 215 on threads 114 before substantial deformation of closure 100 and possibly container 110 occurs. Rotation of closure 100 stops when the resistance friction between closure top contact surface 158 and container top contact surface 160 and the resistance friction between the thread tip blends 212 on pressure faces 213 of threads 116 and thread root blends 214 on pressure faces 215 reaches the set application torque value that typically is applied by a capping machine (not shown). At this positions of engagement, a seal may be provided by the threads 114 and 116 to seal any contents in container 110 from the external environment.

Furthermore, as shown in FIG. 12, depending on the configuration of closure 100, there may also be contact between sealing ring 143 of plug seal device 141 and inner surface 151 of neck region 112 of container 110.

After finalizing capping, closure 100 remains on container 110 until closure 100 is removed and container 110 is opened, for example by a user. With reference to FIG. 8, the contact surface interfaces between closure 100 and container 110 at the start of opening are the same as at the end of translation. At the beginning of rotation, the friction between closure top contact surface 158 and container top contact surface 160 and the resistance friction between the thread tip blends 212 on pressure faces 213 of threads 116 and thread root blends 214 on pressure faces 215 attempt to resist the motion, which is the source of opening torque. After some rotation, the contact again shifts from between thread tip blends 212 on pressure faces 213 of threads 116 and thread root blends 214 on pressure faces 215 of threads 114 to between thread tip blends 202 on application faces 203 of threads 116 and thread root blends 204 on the application faces 205 of threads 114.

With reference to FIG. 9, once closure 100 has been sufficiently translated vertically/axially upwards relative to container 110, contact between closure top contact surface 158 and container top contact surface 160 will cease. Similarly, after sufficient vertical/axial upwards translation of closure 100, contact between outer alignment ring 152 and upper ring 210 or upper portion 118 of neck region 112, and between sealing ring 143 and inner surface 151 will also cease.

Furthermore, as described above and with reference to FIG. 9, as closure 100 is translated vertically/axially upwards, there will also be contact between lower generally horizontal surface 122 of pilfer band 120 and generally horizontally oriented upper surfaces 128 of tamper evident band cams 127 such that frangible connector portions 126 break, allowing closure 100 to be removed from engagement with container 110, while tamper evident band 125 remains in position on container 110.

In the embodiments of FIGS. 2 to 12, it is the presence of micro-surface structures which control both the application torque (ie. the torque required to apply a closure 100 to a container 110) and the removal torque (ie. the torque required to initiate closure 100 to start to become disengaged from container 110).

Engineered micro-surface features that may be provided on various surfaces of the closures 100 and containers 110 described above will now be described with reference to other embodiments as shown in FIGS. 16 to 18. Engineered micro-surface structures in the form of biased micro easy-gliding and/or micro-locking functionality may be provided on a variety of surfaces or portions of surfaces, of the closures and containers described herein, as well as other embodiments of closures and containers. The engineered micro-surface structures can be provided to dramatically increase the effective friction forces at some selected interfacing contact surface areas of containers and closures and/or to substantially reduce or substantially almost eliminate the effective friction forces in other selected interfacing contact surfaces.

The micro-surface structures may be configured and provided so that the effect of the coefficient of friction relating to friction forces created at the contact surfaces of the threads on the removal torque is substantially reduced, minimized and/or made negligible by providing for easy gliding functionality at the contact surface of the threads during opening/removal of the closure 100 on container 110. The micro-surface structures may additionally or alternatively be configured and provided so that the effect of the coefficient of friction relating to the removal of the closure from the container is controlled, which can be done by overwhelming the inherent friction developed by interfacing contact surfaces of the container and the closure with engineered micro-surface structures on interfacing contact surfaces, such as at the top contact surfaces of the container and the closure. Thus, it may be possible to provide a predictable / predetermined level of resistance to movement that is much greater than that of the friction resistance provided by the typical interfacing contact surfaces.

The micro-surface structures may be configured and provided so that a first force required to induce relative movement between two contact surfaces is substantially larger (and typically much larger such as by way of example only in the range of 5 to 20 times larger) than a second force required to induce relative movement between the contact surfaces in a second direction opposite the first direction. The micro-surface structures may also be provided and configured so that the torque required to initiate removal is controlled with greater accuracy. The micro-surface structures may also be provided and configured so that a predetermined contact interface between contact surfaces of a closure and container acts as a master control of opening / removal torque.

Referring now to the schematic views in FIG. 16, forces involved in inducing relative movement between contact surfaces 500A and 500B provided with micro-surface structures according to an embodiment will be described. Each of contact surfaces 500A and 500B are provided in what may be described as a "saw-tooth" type of arrangement, with complementarily shaped, step-like micro-surface structures with a riser 502 and a sloped tread 504, such that riser 502 and tread 504 meet at an acute angle at a corner 505.

The application of forces F1 to F3 will be described on the basis that contact surface 500A is being moved relative to contact surface 500B, which remains stationary in space. However, it is to be understood that contact surface 500B might be the surface being moved, with contact surface 500A remaining stationary in space, or both contact surfaces might be moved in space relative to each other. Furthermore, while forces F1 to F3 are shown as acting generally horizontally / transversely, it is to be understood that, because contact surfaces 500A and 500B are contacting each other, there is a reaction force involved that causes them to be urged towards / away from each other by an applied pressure, and there will be orthogonal forces acting to keep the contact surfaces 500A and 550B generally in contact with each other.

In schematic views (1) and (2) of FIG. 16, surfaces 500A and 500B are generally biased vertically towards each other and have opposed contact surfaces that engage with each other at a contact interface. A generally horizontally directed force F1 is sufficient to move contact surface 500A relative to contact surface 500B to the left, in the general direction of force F1. Treads 504A of contact surface 500A make contact with and glide along treads 504B of contact surface 500B.

In schematic view (3) of FIG. 16, a continued application of force F1 results in treads 504A of contact surface 500A surpassing respective corners 505. Simultaneously, because of the urging of contact surfaces 500A and 500B towards each other, treads 504A are in a substantially parallel and spaced apart relationship with treads 504B of contact surface 500B and a portion of risers 502A of contact surface 500A are in contact with a portion of risers 502B of contact surface 500B. At this point, a continued application of force F1 would result in treads 504A again making contact with and gliding over treads 504B as in schematic view (1).

In schematic view (4) of FIG. 16, force F2 is greater than force F1 (as indicated by the larger arrow) but is insufficient to induce movement of contact surface 500A relative to contact surface 500B because risers 502A of contact surface 500A interfere with and are blocked by risers 502B of contact surface 500B. At least force F3 (schematic view (5) of FIG. 16), which is larger than force F2, is sufficient to induce movement of contact surface 500A relative to contact surface 500B. As shown in schematic view (5) of FIG. 16, under application of at least force F3, risers 502A of contact surface 500A are able to clear risers 502B of contact surface 502B, thereby permitting movement of contact surface 500A relative to contact surface 500B. Force F3 can cause 500A to move upwards and past 500B as a result of deformation at the corner of the treads of 500B.

Through control of the configuration and geometry of the micro-surface structures, forces F1 to F3, may be controlled. For instance, by altering or controlling the acute angle between risers 502 and treads 504 at corners 505, one may alter and control forces F1 and F3 required to allow risers 502A to clear risers 502B.

Micro-surface structures / textures / features may be provided on desired surfaces using, for instance, plasma cutting or laser cutting technology or 3-D printing technology. One desired method of producing the micro-surface structures at selected location areas of surfaces of the closure and container is to for example, use laser or plasma cutting technology and create a negative image of the micro-surface structure that is desired on the molding surface of the injection or compression molding cavity of a molding machine. Upon filling of the cavity with molten plastic, the plastic part (eg. container 110 / closure 100) will reproduce a mirror image of the micro-surface structures on the molding surface. Another method of producing the micro-surface structures on plastic parts is to use a cutting technology such as for example laser or plasma cutting technology directly on a plastic part as a post molding operation.

Micro-surface structures may for example be generally in the size range of 0.005 to 0.250 mm in diameter / length / width ./ height and more particularly in the range of 0.005 to 0.1 mm. In one embodiment, micro-surface structures may be provided on the top contact surfaces of closure 100 and container 110, for instance, closure top contact surface 158 and container top contact surface 160. As shown in the schematic view of FIG. 17A, a contact surface interface may be provided at a contact surface 500A, which may be closure top contact surface 158, and a contact surface 500B, which may be container top contact surface 160. Thus, the micro-surface structures may be configured so that the removal torque (which is a function of force F3) required to remove closure 100 from container 110 would be much greater than the application torque (which is a function of force F1) required to apply closure 100 onto container 100. The micro-surface structures may be configured and provided so that the force required to induce relative movement to remove the closure from the container is substantially larger (and typically much larger such as by way of example only in the range of 5 to 20 times larger) than a the required to induce relative movement between the contact surfaces in the opposite direction.

The micro-surface structures may be configured in such a manner that the removal torque required to remove closure 100 from container 110 is increased to the level where conventional friction forces between other contact surfaces become insignificant and only the torque required to move closure top contact surface 158 to the right relative to container top contact surface 160 is substantially the threshold torque required to initiate and enable removal of closure 100 from container 110. By extension, a lower final closing torque can be applied (relative to typical closure/container combinations without the micro-surface structures) and thereby the mechanism can rely on these micro-locking features to keep the closure 100 in the fully engaged position. Thus, in combination with the modified threads of the container 110 and closure 100 having the micro-surface structures to provide an easy glide function at the thread surface interfaces in the direction of opening of the closure on the container (see FIG. 17C), this system/mechanism relies on the micro-locking structures at the top contact surface (FIG. 17A) interface to keep the closure in the fully engaged position on the container.

By way of further explanation, in some embodiments, micro-surface structures may also be provided at the contact interface on contact surfaces of the threads of a closure 100 and container 110, such as threads 114 and 116, respectively, to further reduce or minimize the effect of conventional friction forces on the removal torque. In particular, micro-surface structures may be applied on the threads to virtually increase the thread lead (i.e. thread pitch) by at least an order of magnitude to provide an easy-glide functionality in one relative direction of movement of the contact surfaces. The micro-level structures can be used to increase the capping resistance during application of the closure to the container, to prevent "over-torquing" of the closure. At the final stages of capping where the pressure faces are already in contact, each incremental increase in capping angle will increase the contact pressure between the threads. Without micro-surface structures on the threads, typically in known configurations, the rotation will continue until the frictional resistance comes into equilibrium with the application torque. With the micro-surface structure mechanism the influence of the friction at the threads can be substantially reduced or substantially eliminated by adding micro-surface structures arranged in such manner that they will prevent the over-rotation of the closure 100 relative to the container 110. In this manner, the final position of the closure 100 on the neck finish of the container 110 is governed through predictable engineered features rather than unpredictable coefficient of friction, and the amount of contact pressure which in turn drives the level of frictional forces during opening can be maintained at a low, desirable level.

FIG. 17B illustrates the effect that the thread lead has on removal torque. As the thread lead (i.e. the thread pitch) decreases, the removal torque increases. Conversely, as the thread lead increases, the removal torque decreases. Typical values of thread lead lie in the 1.7 to 9 mm range. As can be seen in FIG. 17B, if the thread lead/pitch were raised to levels of, for instance, 50 to 80 mm, the removal torque would be reduced to approximately one fifth of what it would be in the typical thread lead range.

The thread lead is determined in part by the thread lead angle in a known relationship, the thread lead angle being defined by the angle between the horizontal and the mean slope of the thread. With reference to FIG. 17C, the micro-surface structures may be configured such that the effective lead angle is increased without substantially altering the slope of the threads. The effective lead angle can be engineered to be close to or substantially 90 degrees.

Specifically, with reference to FIG. 17C, the micro-surface structures on threads 114 of closure 100 may be configured such that at the end of translation of the closure 100 during capping, as described above with reference to FIG. 8, the risers 502A of contact surface 500A on threads 114 of closure 100 abut risers 502B of contact surface 500B on threads 116 of container 110. Thus, at the beginning of the disengagement/removal of closure 100 from container 110, as described above with reference to FIG. 9, treads 504A of contact surface 500A would easily glide on and move relative to treads 504B of contact surface 500B. Due to the slope of treads 504A and 504B relative to the macro-level slope of threads 114 and 116, the lead angle, and thus the thread lead, is effectively increased, thereby reducing the removal torque required to overcome friction created by thread surface to thread surface contact. The micro-surface structures may be configured and provided so that force required to induce relative movement to apply the closure to the container is substantially larger (and typically much larger such as by way of example only in the range of 5 to 20 times larger) than a second force required to induce relative movement between the contact surfaces in a second direction opposite the first direction to remove the closure from the container. In some embodiments the force required to induce relative movement to overcome resistance at the surface of the threads to remove the closure, may be engineered to be very low and may be substantially zero.

Through control of the configuration and geometry of the micro-surface structures, the amount of increase in lead angle, and thus the effect on the removal torque, may be controlled.

It may be appreciated in some embodiments, where micro-surface structures are provided on a portion or all of the top contact surfaces and a portion or all of the contact surfaces of the threads, to apply a closure to the container, it will be necessary to have a torque that provides sufficient force to overcome the resistance at the top contact surfaces and sufficient force to overcome the resistance at the threads. Similarly, to remove a closure form the container, it will be necessary to have a torque that provides sufficient force to overcome the resistance at the top contact surface (which typically will be of a large magnitude and controlling) and sufficient force to overcome the resistance at the threads (but which will typically be very low, or substantially zero).

In some embodiments, where micro-surface structures are provided on a portion or all of the top contact surfaces and a portion or all of the contact surfaces of the threads (such as portions of pressure faces 213 and 215) both the threshold removal torque, i.e. the master control torque, to begin removal of closure 100 and the subsequent removal torque required to fully remove closure 100 may be controlled. Thus, a consistent user experience may be created in which the variability in the removal torque due to the variability in the coefficient of friction may be reduced or minimized.

Therefore, it may be possible, using the same or substantially similar micro-surface structures (e.g. the "saw-tooth" structures as described above) to obtain different properties of the closure and/or container, depending on the manner in which and the contact surfaces to which the micro-surface structures are applied. Thus, one may be able to achieve the easy-gliding property in one direction of relative movement and the increased friction or micro-locking property in a second direction opposite the first, using the same or substantially similar micro-surface features. This may improve efficiency and cost of manufacturing of the closure and/or container, since the same method of applying the micro-surface structures may be used to design and engineer both properties of the closure and/or container, without having to use separate equipment or alter the application method of the micro-surface structures for each desired property.

Another embodiment of a container apparatus 300 such as a flip-top closure will now be described with reference to FIG. 13. Container apparatus 300 may be configured as a generally right cylindrical tubular shaped shell 301 that may be sealingly secured to an open body portion of a container body (not shown). Container shell 301 may have a circular disc-shaped top wall 302 and a generally right vertical cylindrically tubular shaped sidewall 305. A generally circular opening 310 is provided in and through top wall 302, surrounded by a circumferential, raised ring 312 protruding from top wall 312. Opening 310 includes a cylindrical inner surface 311 and provides an opening through which material stored in the container body may pass.

Container apparatus 300 also includes a flip lid 318 that has a generally circular disc shaped top wall 319 from which extends a generally vertical cylindrical tubular shaped side wall 320. Side wall 320 has an annular edge portion 314. Top wall 302 of shell 301 has annular vertical wall 304 which is positioned to lie near an inner top edge 306 of side wall 305. Annular vertical wall 304 and inner top edge 306 co-operate to provide an annular groove 316. Annular groove 316 is configured and adapted to releasably engage annular edge portion 314 of side wall 320 of flip lid 318. Thus side wall

320 is configured and shaped to be complementary to the shape of top wall 302 and annular groove 316 so that, when flip lid 318 engages with shell 301, container apparatus 300 is moved from an open position to a closed position and an upper inner surface (not visible) of flip lid 318 may be generally located flush with and adjacent to top wall 302.

Flip lid 318 may be hingedly connected to body 302 via hinge 324. Hinge 324 may be formed and constructed using techniques known to a person skilled in the art. Flip lid 318 and shell 301 may be formed separated and then assembled and connected at hinge 324 to produce container apparatus 300. A recess 325 in shell side wall 305 and a recess 326 in lid side wall 320 permits hinge 324 to pivot allowing lid 318 to pivot between an open position (as shown in FIG. 13) and a closed position (not shown) where edge portion 314 is received in annular groove 316 annular edge portion 314 of side wall 320 of flip lid 318.

Flip lid 318 may also include a generally circular cylindrically tubular shaped spud or stopper 326 configured to be received in opening 310 with a form locking or interference fit. In particular, spud 326 may be provided with spud ring 328 protruding from the distal end of spud 326. If present, spud ring 328 is dimensioned and configured with a generally cylindrical outer surface 334 to produce a form locking or interference fit with inner surface 311 of opening 310.

It will be appreciated that an application of force will be required to flip up flip lid 318 to overcome the friction force associated with the interference fit between spud 326 and/or ring 328 and inner surface 311 of opening 310. A user may apply this force which causes moment around hinge 324, which, in turn, causes relative movement of spud 326 with respect to inner surface 311 of opening 310.

Container apparatus 300 may be applied and connected to a container body in a known manner, for example, by being screwed or snapped on. When container apparatus 300 is applied to a container, a user typically chooses to open and close flip lid 318 instead of removing entire container apparatus 300 each time the contents of container are to be accessed.

In some embodiments, shell 301 may also have other cross sectional shapes such as a circular or polygonal shape. The shape of shell 301 may be chosen so that sidewall 305 is flush with a sidewall of the container to which container apparatus 300 is applied in a known manner.

Another embodiment of a container apparatus including a closure 400 and a container 412 that may be a bottle, will now be described with reference to FIG. 14. Closure 400 may be generally configured as a plug with a generally cylindrical or frusto-conical plug body 402 having two opposing, generally circular first and second end faces 404 and 406 and a cylindrical or right circular cone shaped side surface 408.

Closure 400 may be made from a synthetic resin or plastic material such that it has elastic properties and can be partially compressed in the radial direction when subject to radially applied compressive forces.

Closure 400 is intended for inserting into and closing of a container 412. Container 412 may be made of glass or plastic or other materials known to a person skilled in the art and may generally be less prone to elastic deformation in a radial direction than closure 400. In the embodiment shown, container 412 has a generally right cylindrical rigid neck 414 that defines a bottle opening 416.

The diameter of plug body 402 (which may vary in the case of a frusto-conical shaped body), is configured to be at least through part of its length to be larger than the diameter of opening 410 of container 412 such that, upon insertion of closure 400 into bottle 412, neck 414 of container 412 exerts a radially compressive force onto plug body 402. In response to the radially compressive force, hoop stresses (i.e. circumferential stresses) in plug body 402 cause cylindrical side surface 408 to press against neck 414. As plug body 402 is progressively pressed into neck 414 by a downward force, plug body 402 is progressively compressed. Thus, closure 400 forms an interference or form locking fit with surrounding neck 414.

Closure 400 may be partially or fully inserted into neck 414 of container 412. For instance, during initial plugging at a manufacturer or bottling plant, closure 400 may be fully inserted such that second end surface 408 does not protrude out of opening 410. Closure 400 may be fully inserted in such a manner that second end surface 408 is flush with an end rim 416 of neck 414 surrounding opening 410. For instance, container 412 may be a wine bottle filled with wine and "corked" using closure 400.

Closure 400 may be removed in a variety of ways, including, for example, by using a corkscrew. In order to remove closure 400, a force is applied to pull closure 400 vertically/axially upward out of neck 414.

With reference to FIG. 18, a similar control of the removal force required to remove a spud, such as spud 326, or a plug, such as closure 400, from their corresponding openings may be achieved. For instance, in the case of container apparatus 300, micro-surface structures may be provided on spud

326 and/or spud ring 328 and inner surface 311 of opening 310. Similarly, micro-surface structures may be provided on side surface 408 of closure 400 and internal surface 418 of neck 414 of container 412.

Referring to FIGS. 19 and 20, selected regions 600 of micro-surface structures may be provided on some or all surfaces where closure 100 and container 110 may contact each other during application and removal of closure 100. For instance, if plug sealing device 140 or 141 is present, micro-surface structures may be provided on a portion of sealing section 148 and/or sealing ring 143. In some embodiments, regions 600 of micro-surface structures may be provided on thread tip blends 202, thread root blends 204, thread crests 206 and thread roots 208.

Depending on the locations of the regions 600, the micro-surface structures may be configured differently so that a desired effect is achieved.

In some embodiments, the micro-surface structures may be provided and configured so that a contact interface other than the contact interface between the top contact surfaces acts as the master control torque, determining the threshold removal torque required to remove the closure from the container.

FIGS. 21A to 21F show some embodiments for possible micro-surface structures. In particular, the micro-surface structures may be ramp-shaped or wedge-shaped, may have the shape of a portion of an ellipsoid, may be dimple-shaped, may be shaped as a portion of a triangular prism, may be a portion of a cylinder, and may be irregular. The micro-surface structures may have another shaped not depicted here but that is sufficient to allow for control and predetermination of a desired force or torque as described herein. Where there are multiple regions of micro-surface structures, different shapes and types of micro-surface structures may be employed to achieve the desired control of the removal torque or requisite forces.

With reference to FIG. 22, an example injection molding system 3100 is illustrated schematically that may be employed and/or adapted to form any of the closures or containers depicted and described herein, or preforms with neck regions, such preforms having body portions which can be blown to form final form containers. System 3100 may in general be conventionally configured and may comprise an injection mold 3116 having a cavity mold half 3102 and an opposite core mold half 114. System 3100 may also include an injection unit 3104, a clamping unit 3106 and a treatment unit. System 3100 may also include a moving apparatus 3108. The operation of system 3100 and its components may be controlled by a controller 3105, such as a programmable logic controller (PLC) or industrial computer. Communication links between various components of system 3100 and controller 3105 may be provided and such links may be wired and/or wireless. Cavity mold half 3102 may contain a plurality of mold cavities 3103 and cavity mold half 3102 may be attached to a stationary platen 3110. Core mold half 3114 may have a corresponding plurality of mold cores 3127 and the core mold half 3114 may be attached to a moving platen 3115. Thus the core mold half 3114 may be capable of reciprocating movement in the X direction relative to the cavity mold half 3102 between a mold open and a mold closed position. The stationary platen 3110 and the clamping unit 3106 may be linked by tie bars.

Moving apparatus 108 may include a support that may be a Z axis beam 3118 (ie. a beam extending generally parallel to the Z axis). The Z axis may be typically oriented horizontally but other orientations of the X-Y-Z axes are possible. Z axis beam 3118 may be provided with a relatively high degree of rigidity, and thus reduce the amount of deflection of Z axis beam 3118 as a carriage 3120 carrying a tool 3122 moves along the Z axis beam 3118. Z axis carriage may be configured to permit the mounting thereto of tool 3122 (which may be an End of Arm Tool). Tool 3122 may be what is commonly referred to as a “multi-position take-off device” and may include a plurality of part carriers 3124. The part carriers 3124 may be operable to receive molded parts, ejected from mold 3116 and then facilitate their transfer to treatment unit 3112.

In one embodiment, mold cavities 3103 may be configured to form container 110. In another embodiment mold cavities may be configured to form closure 100. As indicated above, in some embodiments, the surfaces of the component(s) forming the mold cavities may have been created in particular shapes /configuration by known techniques such as by way of example only, laser ablation or discharge machining of the molding surface in the mold cavities 3101 in system 3100. One desired method of producing the micro-surface structures at selected location areas of surfaces of the closure or container is to for example, use laser or plasma cutting technology and create a negative image of the micro-surface structure that is desired on the molding surface of the injection or compression molding cavity of a molding machine.

Alternatively, the micro-surface structures may be post-formed on surfaces of the closure 100 and/or container 110 after they have been formed in a system like system 3100, by a variety of known types of processes/techniques such as by way of example only, laser cutting such as with computer controlled lasers, erosion and/or deposition techniques/processes .

In general operation, when cavity mold half 3102 and core mold half 3114 are in a closed configuration, the mold is clamped shut by the clamping unit and injected material is supplied to the mold cavities 3103 to form the closures or other molded parts. At a suitable time, mold 3116 can be opened separating the core mold half 3114 from the cavity mold half 3102 in the X direction. This allows tool 3122 with part carriers 3124 to be moved with the Z axis carriage 3120 along Z axis beam 3118 to an inbound position between cavity mold half 3102 and core mold half 3114 so that the part carriers are appropriately aligned with mold cores 3127 of core mold half 3114. At such an inbound position the parts that have been formed in mold 3116 can be transferred to the part carriers 3124 of the tool 3122 in a manner known to those skilled in the art. Once the parts are transferred to the tool 3122, the tool can be moved again to an outbound position along the Z axis beam 3118 to allow system 3100 to commence making a new set of parts. Tool 3122 can move to such an outbound position where the tool is appropriately aligned with a treatment device 3128 of treatment unit 3112 so that the parts may be appropriately treated such as by being thermally conditioned while being held by tool 3122.

Of course, the above described embodiments are intended to be illustrative only and in no way limiting. The described embodiments of carrying out the invention are susceptible to many modifications of form, arrangement of parts, details and order of operation. Other variations are possible.

When introducing elements of the present invention or the embodiments thereof, the articles “a,” “an,” “the,” and “said” are intended to mean that there are one or more of the elements. The terms “comprising,” “including,” and “having” are intended to be inclusive and mean that there may be additional elements other than the listed elements.

WHAT IS CLAIMED IS:

1. A container apparatus comprising a combination of a first part) and a second part for releasably closing an opening in said first part, said apparatus comprising:

   a contact interface between a contact surface (160, 205, 500B) of the first part and a contact surface (158, 203, 500A) of the second part, the contact surfaces comprising co-operating micro-surface structures operable such that a first force is required to induce relative movement between the contact surfaces in a first direction that is substantially larger than a second force required to induce relative movement in a second direction opposite the first direction.

2. A combination as claimed in claim 2 wherein said contact surfaces (160, 158; 205, 203) comprise respective co-operating sealing surfaces of said first part and said second part.

3. A container apparatus as claimed in claims 1 or 2 wherein said first part is a container (110) and said second part is a closure (100).

4. A combination as claimed in claim 3 wherein said contact surfaces comprise respective co-operating top sealing surfaces (160, 158) of said container and said closure.

5. A combination as claimed in claim 4 wherein in operation said first force is required to induce relative movement between the contact surfaces in said first direction to initiate removal of a closure engaged with said container from engagement with said container.

6. A combination as claimed in claim 3 wherein said contact surfaces comprise respective co-operating contact surfaces (205, 203) of threads (114, 116) of respective said container and said closure.

7. A combination as claimed in claim 6 wherein said contact surfaces are respective co-operating pressure surfaces (205, 203) of threads (114, 116) of respective said container and said closure.

8. A combination as claimed in claims 6 or 7 wherein in operation said first force is required to induce relative movement between the contact surfaces in said first direction to apply the closure to the container.

9. A combination as claimed in claims 6, 7 or 8 wherein in operation said second force is required to induce relative movement between the contact surfaces in said second direction to permit removal of the closure engaged with the container.

10. A combination as claimed in claim 9 wherein said first force is of a magnitude of in the range of 5 to 20 times greater than the second force.

11. A combination as claimed in any one of claims 6 to 10 wherein said second force is of a magnitude that provides for a low level of resistance between said contact surfaces.

12. A combination as claimed in any one of claims 6 to 11 wherein said second force is of a magnitude to provide substantially no resistance between said contact surfaces.

13. A combination as claimed in claims 4 or 5 wherein:

said contact interface comprises a first contact interface between a first contact surface (160) of the container (110) and a first contact surface (158) of the closure (100); and

said combination further comprises a second contact interface between a second contact surface (205) of the container (110) and a second contact surface (203) of the closure (100) the second contact surfaces comprising co-operating micro-surface structures operable such that a third force is required to induce relative movement between the contact surfaces in a third direction that is substantially larger than a fourth force required to induce relative movement in a fourth direction opposite the third direction.

14. A combination as claimed in claim 13 wherein said second contact surfaces are respective co-operating surfaces of threads (114, 116) of respective said container (110) and said closure (100).

15. A combination as claimed in claims 13 or 14 wherein in operation said third force is required to induce relative movement between the contact surfaces in said third direction to apply the closure to the container.

16. A combination as claimed in claims 13, 14 or 15, wherein in operation said first and fourth forces are required to induce relative movement between the first contact surfaces and second contact surfaces respectively to permit removal of the closure engaged with the container.

17. A combination as claimed in any of claims 13 to 16, wherein said third force is of a magnitude of in the range of 5 to 20 times greater than the fourth force.

18. A combination as claimed in any one of claims 13 to 17 wherein said fourth force is of a magnitude that provides for a low level of resistance between said second contact surfaces.

19. A combination as claimed in any of claims 13 to 18 wherein said fourth force is of a magnitude to provide substantially no resistance between said contact surfaces.

20. A combination as claimed in any one of claims 13 to 19 wherein said first force is of a magnitude of in the range of 5 to 20 times greater than the second force, to provide for a high level of resistance between said contact surfaces against movement in said first direction.

21. A combination as claimed in any one of claims 3 to 20 wherein in operation said first force is of a magnitude which substantially controls the removal torque required to initiate removal of the closure from the container when the closure is fully engaged with the container.

22. A combination as claimed in any one of claims 1 to 12 wherein the micro-surface structures are operable to provide a micro-locking functionality such that said first force is of a high magnitude to provide for a high level of resistance between said contact surfaces.

23. A combination as claimed in claim 22 wherein in operation said micro-locking functionality substantially controls the removal torque required to initiate removal of the closure from the container.

24. A combination as claimed in any one of claims 13 to 21 wherein the micro-surface structures on said first contact surfaces are operable to provide a micro-locking functionality such that said first force is of a high magnitude to provide for a high level of resistance between said first contact surfaces.

25. A combination as claimed in claim 24 wherein in operation said micro-locking functionality substantially controls the removal torque required to initiate removal of the closure from the container.

26. A combination as claimed in any one of claims 1 to 25 wherein said micro-surface structures are configured in one or more of the following shapes: a saw-tooth shape; a ramp-shape; a

wedge-shape, a shape of a portion of an ellipsoid; a dimple-shape; shaped as a portion of a triangular prism; shaped as a portion of a cylinder; and irregular shaped.

27. A combination as claimed in claim 1 wherein said first part is a container (412) having a neck (414) with an opening (410) and said second part is a plug (402), which is elastically deformable and operable to be inserted into the opening (410) in said neck (414) to seal said opening (410), and wherein said contact surface of the container is an interior surface of said neck and said contact surface of the plug is an exterior surface of said plug.

28. A combination as claimed in claim 27 wherein in operation said first force is required to induce relative movement between the contact surfaces in a first direction to remove the plug (402) from the opening of the neck (414) when the plug is engaged in the opening.

29. A combination as claimed in claims 27 or 28 wherein said container is a bottle.

30. A combination as claimed in claim 1 wherein said first part is a container shell (301) adapted for connection to a container body, said shell having an opening (310), and wherein said second part comprises a spud (326) which is elastically deformable and operable to be inserted into the opening (310) in said container shell (301) to seal said opening, and wherein said contact surface of the container shell comprises an interior surface (311) surrounding said opening (310) and said contact surface of the spud (326) comprises an exterior surface of said spud.

31. A combination as claimed in claim 30 wherein in operation said first force is required to induce relative movement between the contact surfaces in a first direction to remove the spud (326) from the opening when the spud is engaged by the interior surface (311) in the opening.

32. A method of manufacturing a container apparatus as claimed in any one of claims 1 to 31, comprising:

(a) forming said first part;

(b) applying said micro-surface structures to said contact surface of the first part.

33. A method as claimed in claim 32 further comprising:

(c) forming said second part;

(d) applying micro-surface structures to said contact surface of the second part.

34. A method as claimed in claims 32 or 33 wherein step (a) and (b) are performed together in a molding machine.

35. A method as claimed in claim 32, 33 or 34 wherein step (c) and (d) are performed together in a molding machine.

36. A method as claimed in any one of claims 32 to 35 wherein said first part is formed by injection molding.

37. A method as claimed in any one of claims 32 to 36 wherein said second part is formed by injection molding.

38. A method as claimed in claims 32 wherein said micro-surface structures are applied to said first part after step (a).

39. A method as claimed in claims 33 or 38 wherein said micro-surface structures are applied to said second part after step (c).

40. A method as claimed in claims 38 or 39 wherein said micro-surface structures are applied to said first part using plasma cutting or laser cutting technology.

41. A method as claimed in claims 39 or 40 wherein said micro-surface structures are applied to said first part and said second part using one or more of plasma cutting or laser cutting technology.

42. A method of manufacturing a container apparatus as claimed in any of claims 1 to 31, wherein at least one of said first part and said second part is formed with micro-surface structures formed on a contact surface, using 3-D printing technology.

43. A first part of a container apparatus for use with a second part of a container apparatus, said second part for releasably closing an opening (119) in said first part, said first part comprising: a contact surface (160, 205, 500B) operable to engage with a contact surface (158, 203, 500A) of the second part at a contact interface, the contact surfaces comprising co-operating micro-surface structures operable such that when said contact surface of said first part is engaged with said contact surface of said second part, a first force is required to induce relative movement between the contact surfaces in a first direction that is substantially larger

than a second force required to induce relative movement in a second direction opposite the first direction.

44. A first part as claimed in claim 43 wherein said first part is a container (110) and said second part is a closure (100).

45. A first part as claimed in claim 44 wherein said contact surfaces of said first and second parts comprise respective co-operating top sealing surfaces (160, 158) of said container and said closure.

46. A first part as claimed in claim 45 wherein in operation said first force is required to induce relative movement between the contact surfaces in said first direction to initiate removal of said closure engaged with said container from engagement with said container.

47. A first part as claimed in claim 44 wherein said contact surfaces comprise respective co-operating contact surfaces (205, 203) of threads (114, 116) of respective said container and said closure.

48. A first part as claimed in claim 47 wherein in operation said first force is required to induce relative movement between the contact surfaces in said first direction to apply the closure to the container.

49. A first part as claimed in any one of claims 44 to 46, wherein:

said contact interface comprises a first contact interface between a first contact surface (160) of the container and a first contact surface (158) of the closure; and

said first part further comprises a second contact surface (205) of the container operable to engage with a second contact surface (203) of the closure to form a second contact interface, the second contact surfaces comprising co-operating micro-surface structures operable such that a third force is required to induce relative movement between the contact surfaces in a third direction that is substantially larger than a fourth force required to induce relative movement in a fourth direction opposite the third direction.

50. A first part as claimed in claim 49 wherein said second contact surfaces are respective co-operating surfaces (205, 203) of threads (114, 116) of respective said container and said closure.

51. A first part as claimed in claim 50 wherein in operation said first force is required to induce relative movement between the contact surfaces in said first direction to apply the closure to the container.

52. A first part of a container apparatus for use with a second part of a container apparatus, said first part for releasably closing an opening (119) in said second part, said first part comprising: a contact surface (158, 203, 500A) operable to engage with a contact surface (160, 205, 500B) of the second part at a contact interface, the contact surfaces comprising co-operating micro-surface structures operable such that when said contact surface of said first part is engaged with said contact surface of said second part, a first force is required to induce relative movement between the contact surfaces in a first direction that is substantially larger than a second force required to induce relative movement in a second direction opposite the first direction.

53. A first part as claimed in claim 52 wherein said first part is a closure (100) and said second part is a container (110).

54. A first part as claimed in claim 53 wherein said contact surfaces of said first and second parts comprise respective co-operating top sealing surfaces (158, 160) of said closure and said container.

55. A first part as claimed in claim 54 wherein in operation said first force is required to induce relative movement between the contact surfaces in said first direction to initiate removal of said closure engaged with said container from engagement with said container.

56. A first part as claimed in claim 53 wherein said contact surfaces comprise respective co-operating contact surfaces (203, 205) of threads (116, 114) of respective said closure and said container.

57. A first part as claimed in claim 51 wherein said contact surfaces are respective co-operating pressure surfaces of threads of respective said closure and said container.

58. A first part as claimed in claims 56 or 57 wherein in operation said first force is required to induce relative movement between the contact surfaces in said first direction to apply the closure to the container.

59. A first part as claimed in claims 54 or 55 wherein:

said contact interface comprises a first contact interface between a first contact surface (160) of the container and a first contact surface (158) of the closure; and

said first part further comprises a second contact surface (205) of the container operable to engage with a second contact surface (203) of the closure to form a second contact interface, the second contact surfaces comprising co-operating micro-surface structures operable such that a third force is required to induce relative movement between the contact surfaces in a third direction that is substantially larger than a fourth force required to induce relative movement in a fourth direction opposite the third direction.

60. A first part as claimed in claim 58 wherein said second contact surfaces are respective co-operating surfaces (205, 203) of threads (114, 116) of respective said container and said closure.

61. A first part as claimed in claim 59 wherein in operation said first force is required to induce relative movement between the contact surfaces in said first direction to apply the closure to the container

62. A container apparatus comprising a container (110) and a closure (100), said apparatus comprising:

a contact interface between a contact surface of the container (110) and a contact surface of the closure (100), the contact surfaces (160, 205, 500B; 158, 203, 500A) of the container (110) and closure (100) at the contact interface comprising co-operating micro-surface structures operable to provide a micro-locking force that resists relative movement between the contact surfaces in a direction to dis-engage the closure from the container, that is substantially greater than a friction force generated by other contact interfaces between other surfaces of the closures and other surfaces of the container that resists relative movement between the contact surfaces in a direction to dis-engage the closure from the container.

63. A combination as claimed in claim 62 wherein said contact surfaces comprise respective co-operating sealing surfaces of said container and said closure.

64. A combination as claimed in claim 62 wherein said contact surfaces comprise respective co-operating top sealing surfaces (160, 158) of said container and said closure.

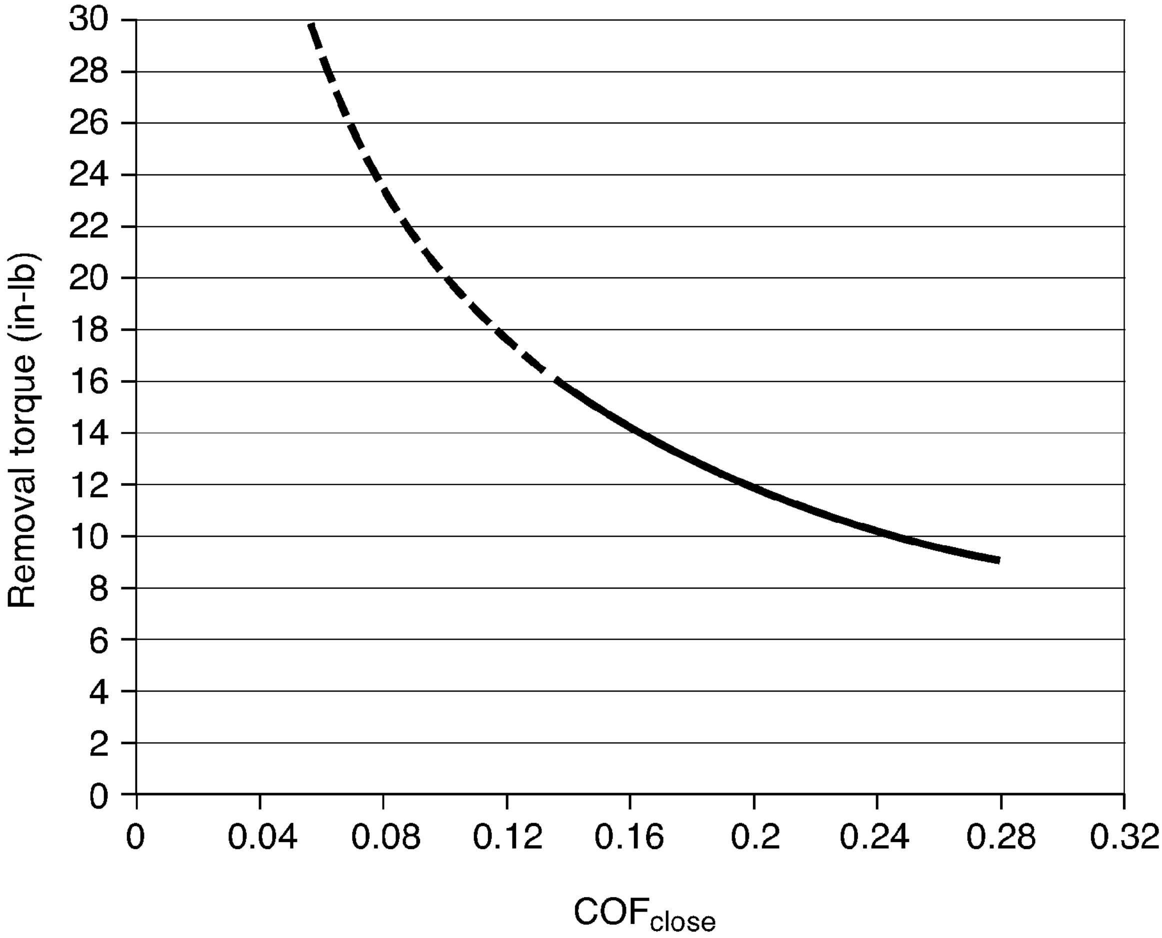
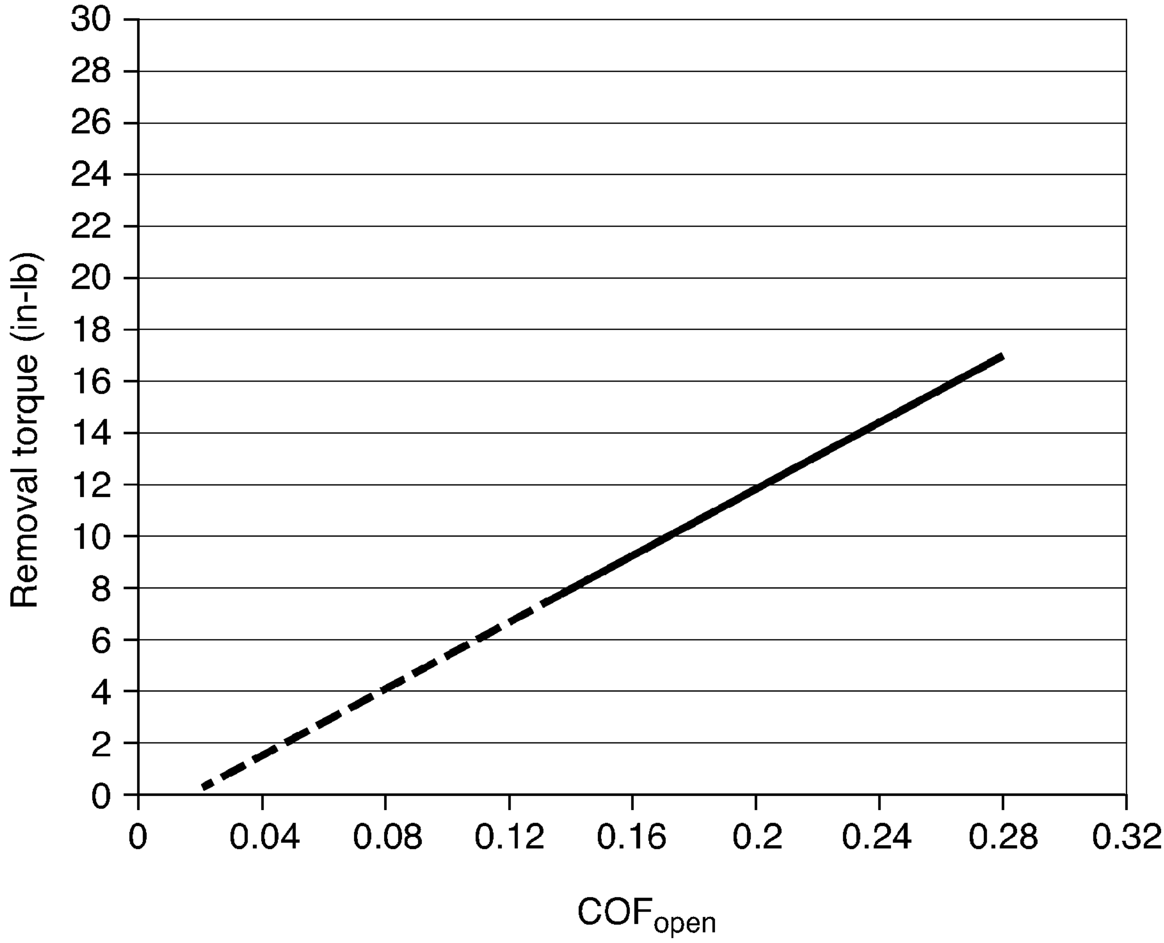

30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Removal torque (in-lb)
0
0.04
0.08
0.12
0.16
0.2
0.24
0.28
0.32
COF_close

FIG. 1A



Removal torque (in-lb)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
0.04
0.08
0.12
0.16
0.2
0.24
0.28
0.32
COF$_{open}$

FIG. 1B

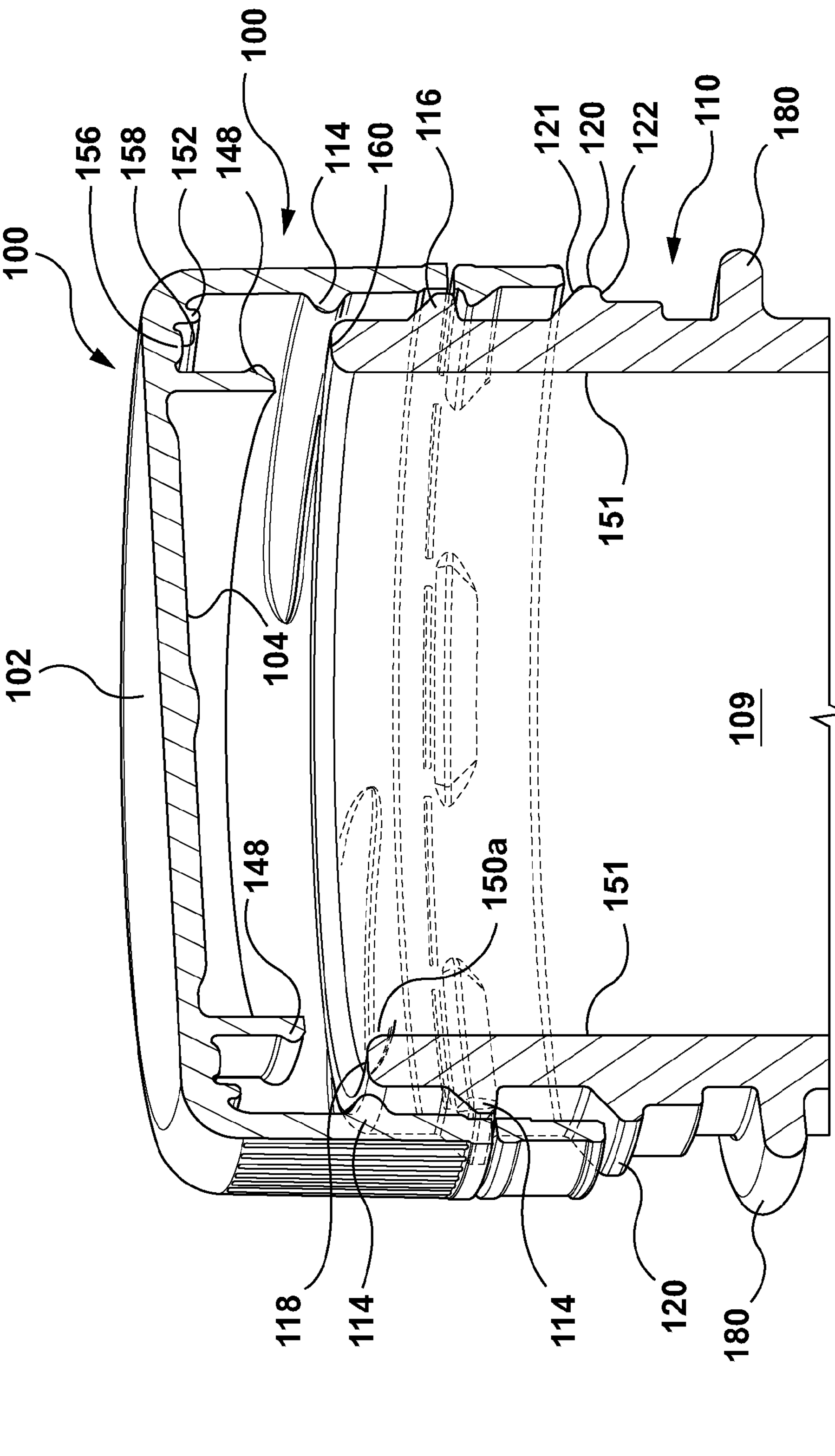

100
156
158
152
148
100
114
160
116
121
120
122
110
180
151
102
104
109
151
148
150a
118
114
114
120
180

FIG. 2

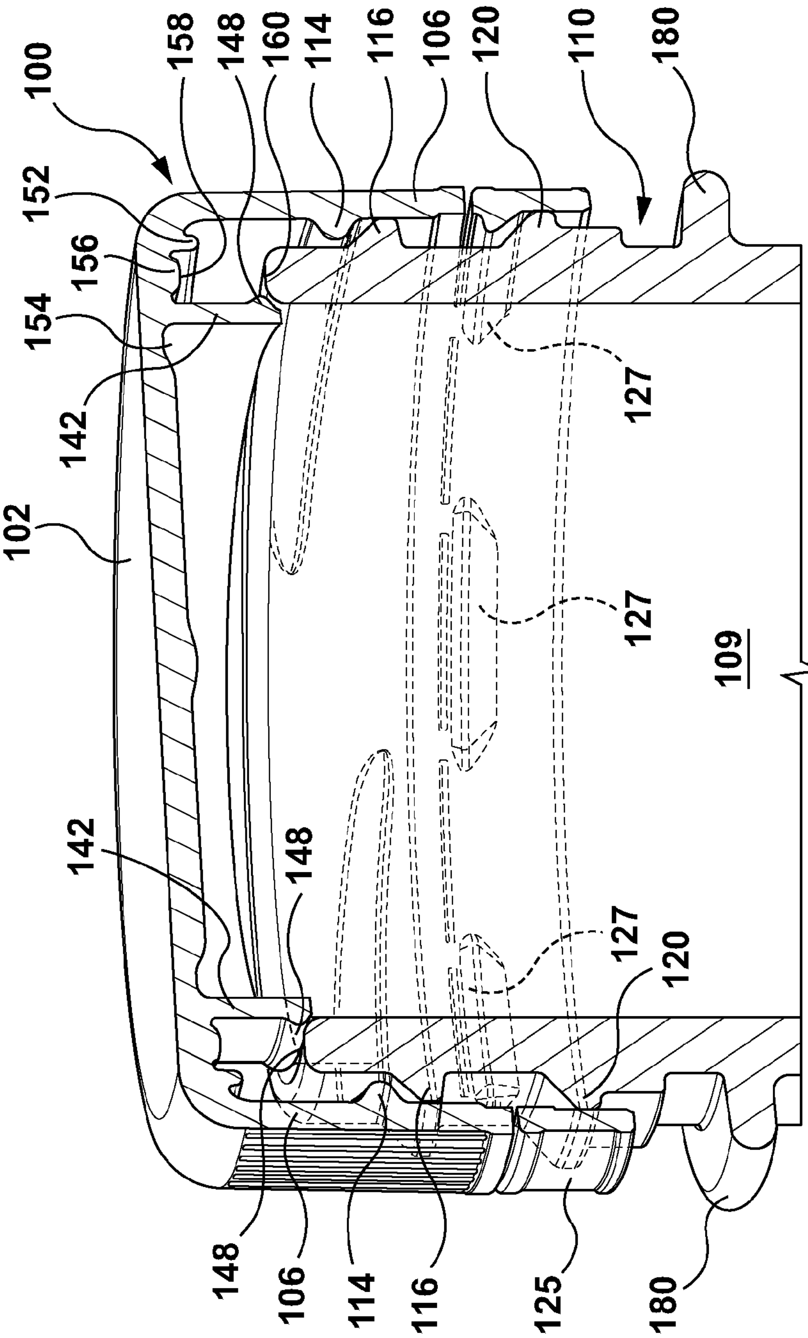

100
152
158
148
160
114
116
106
120
110
180
156
154
142
102
127
127
109
142
148
127
120
148
106
114
116
125
180

FIG. 3

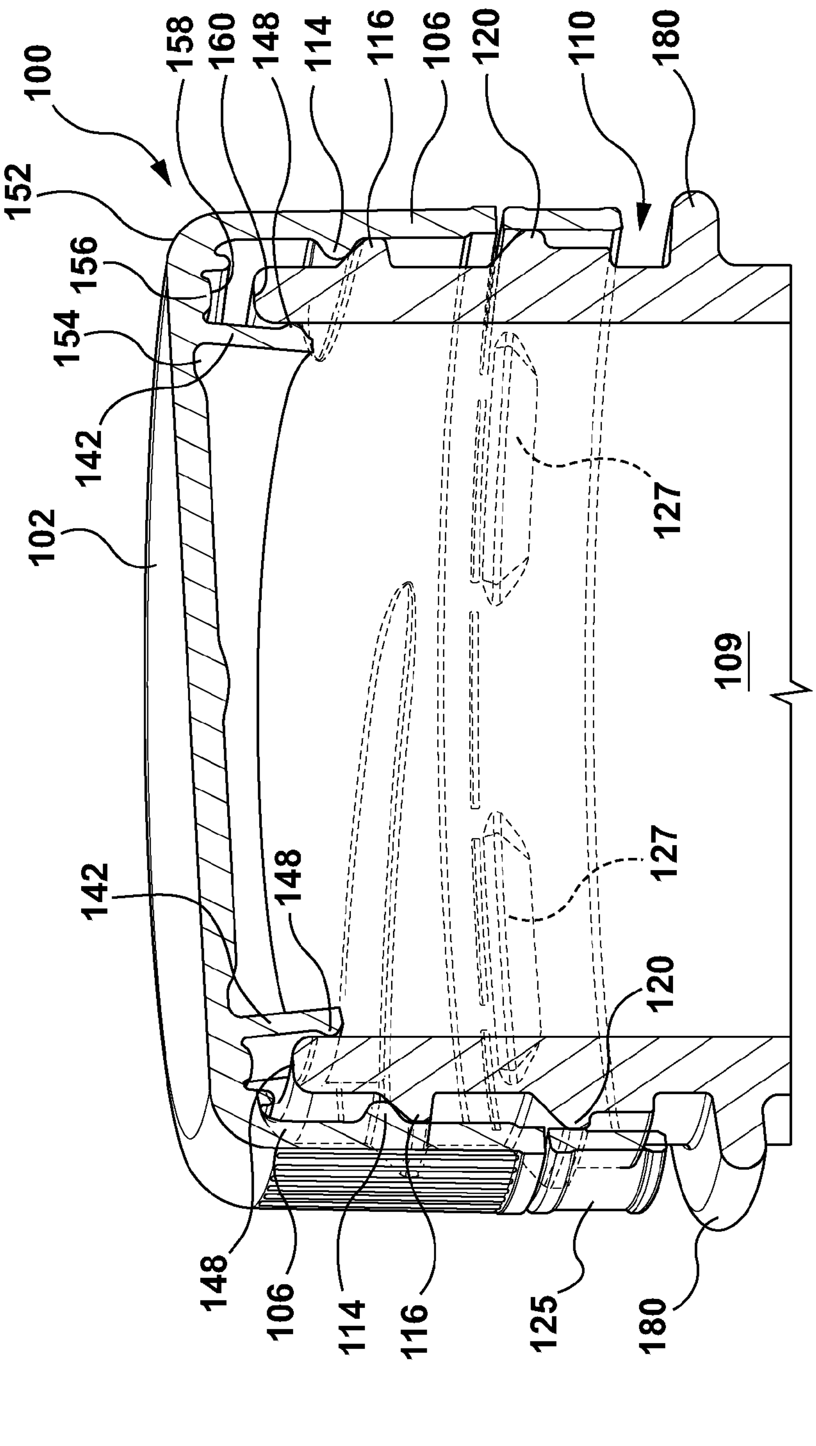

100
152
158
160
148
114
116
106
120
110
180
156
154
142
102
127
109
127
142
148
120
148
106
114
116
125
180

FIG. 4

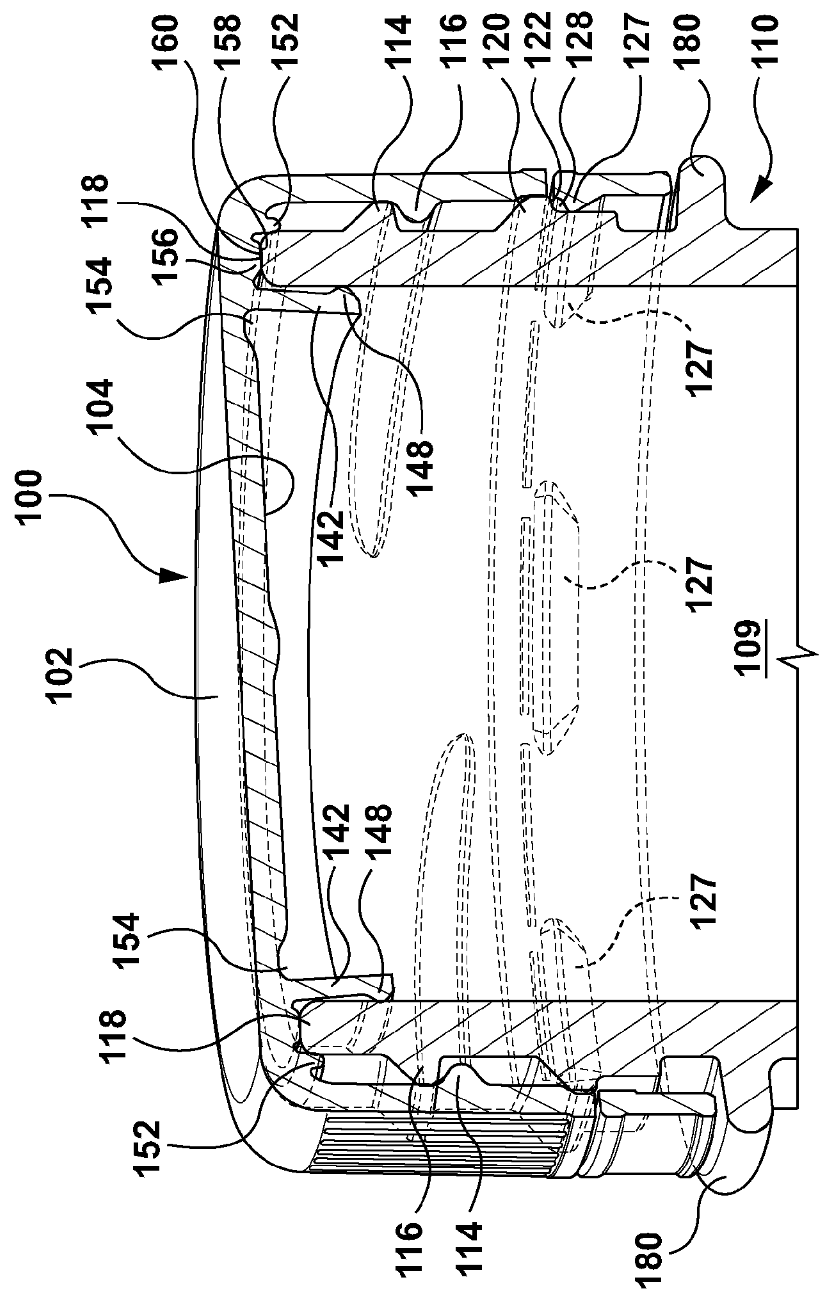

160
158
152
114
116
120
122
128
127
180
110
118
156
154
104
148
142
100
102
127
109
142
148
154
118
152
116
114
180

FIG. 5

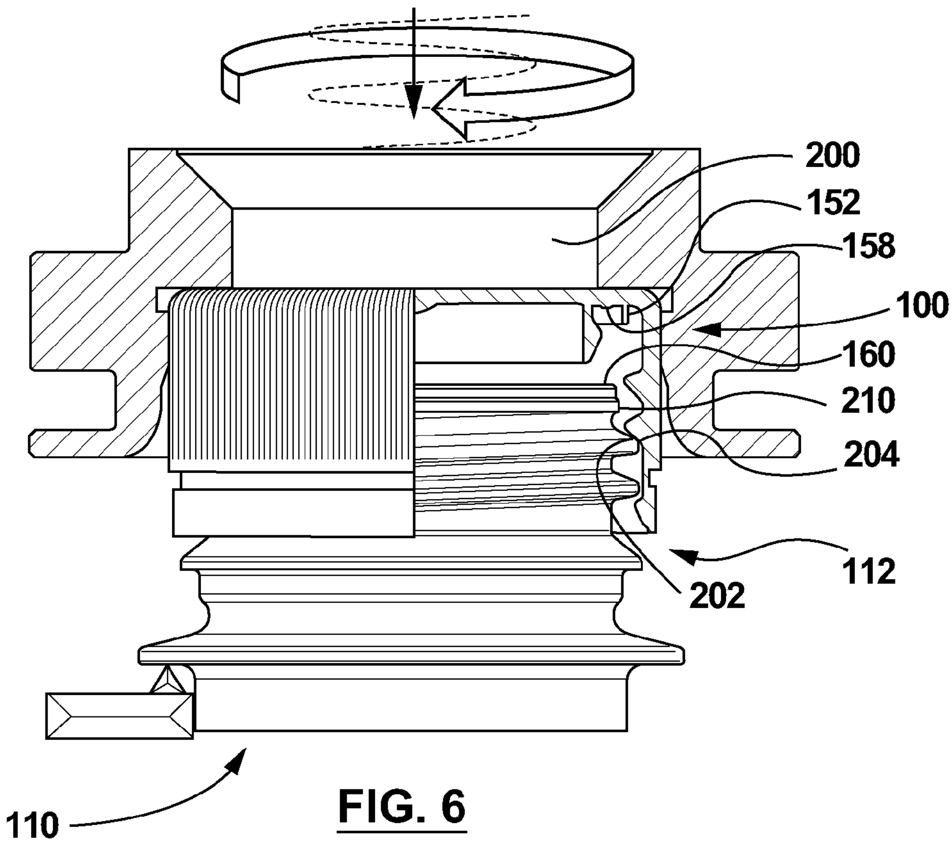

200
152
158
100
160
210
204
112
202
110

FIG. 6

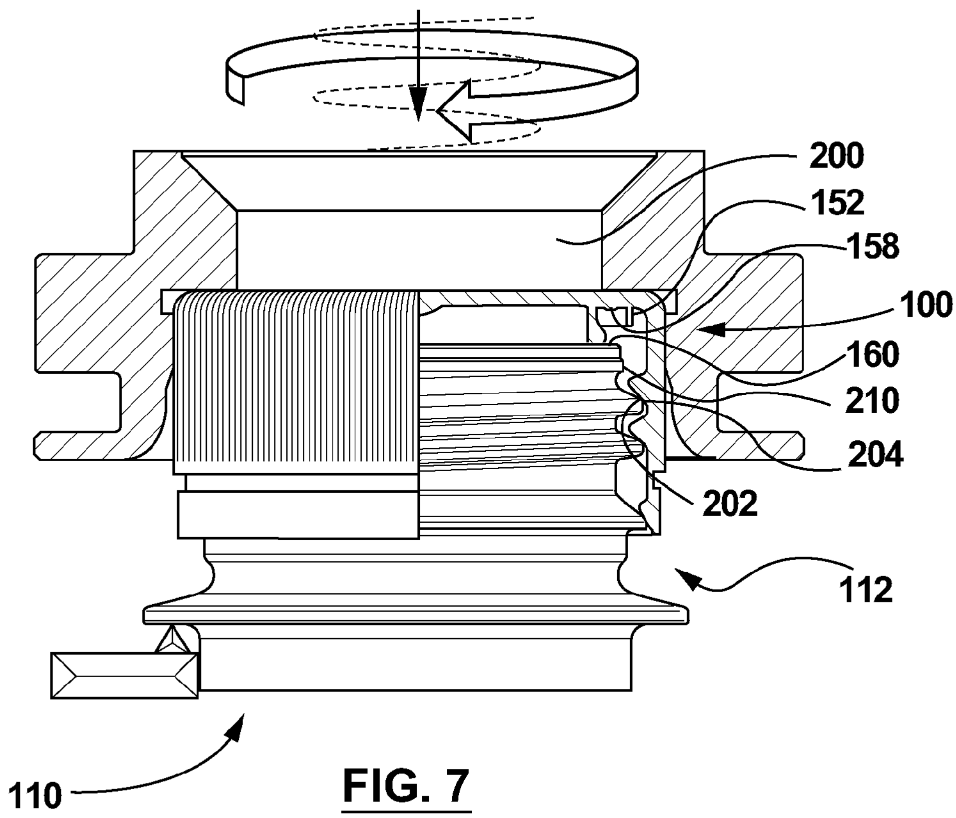

200
152
158
100
160
210
204
202
112
110

FIG. 7

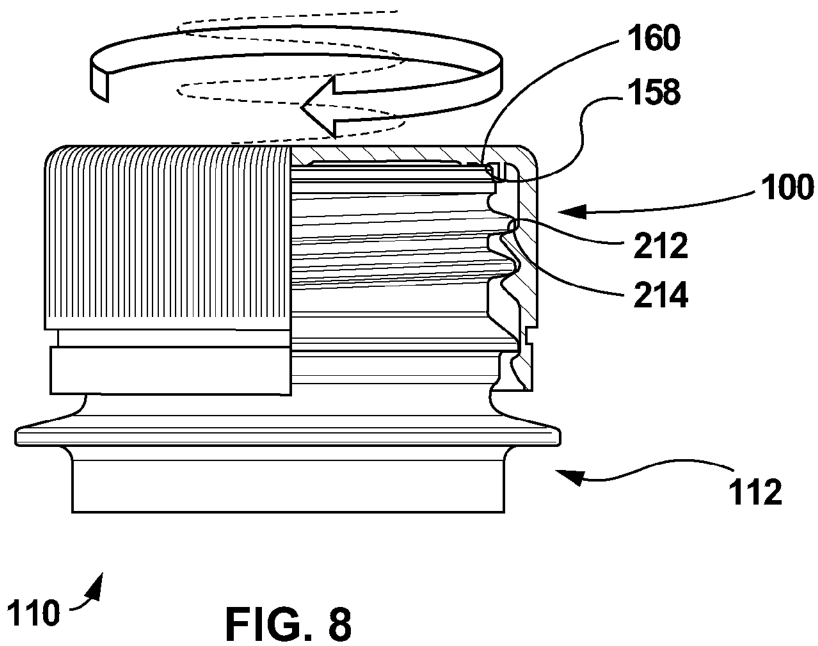


FIG. 8

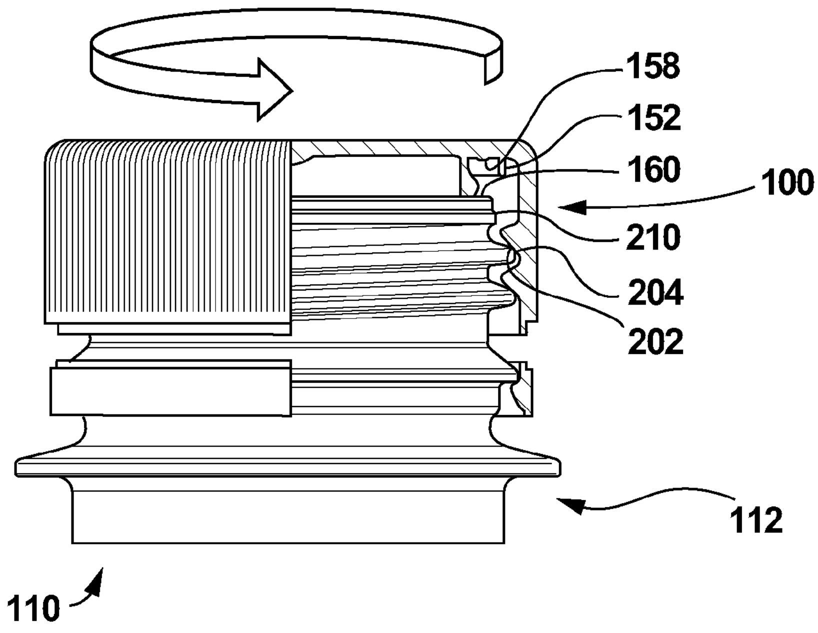


FIG. 9

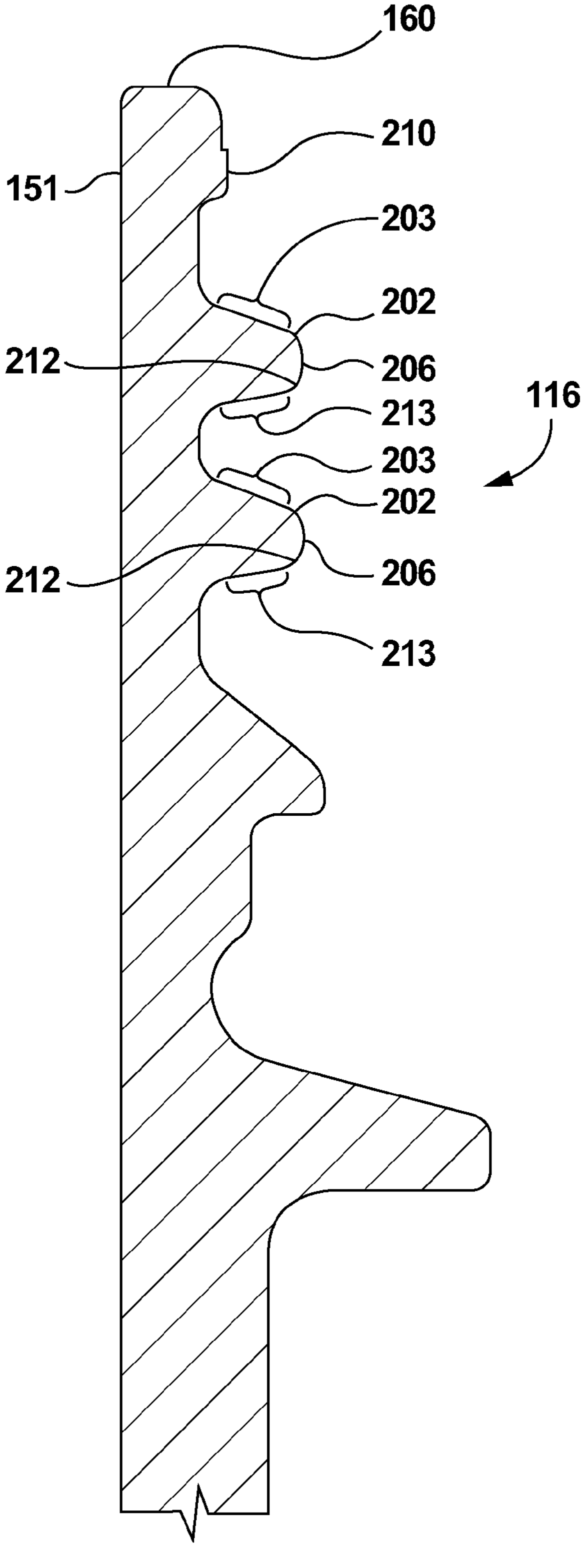

160
210
151
203
202
212
206
213
203
202
212
206
213
116

FIG. 10

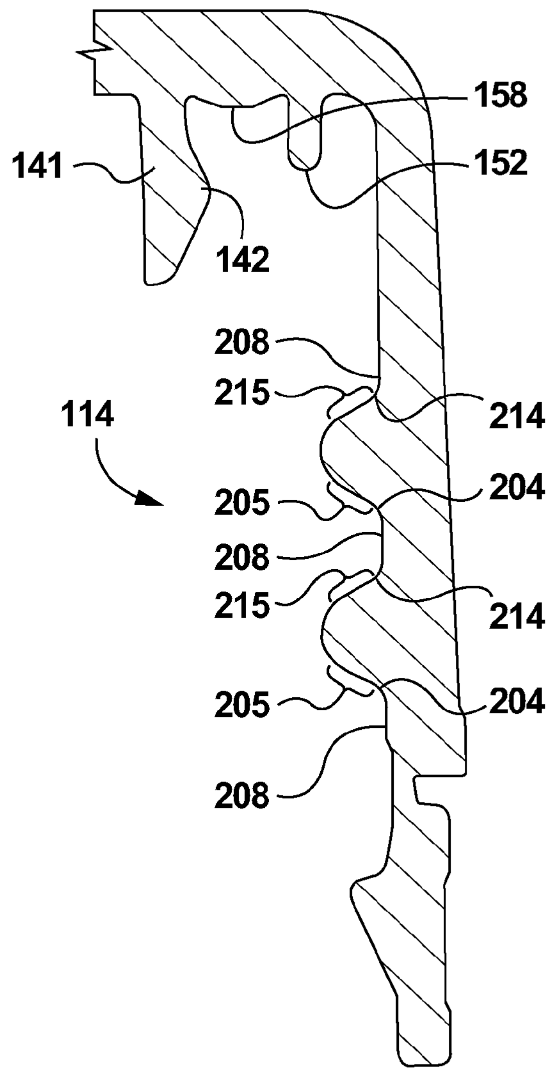

158
141
152
142
208
215
214
114
205
204
208
215
214
205
204
208

FIG. 11

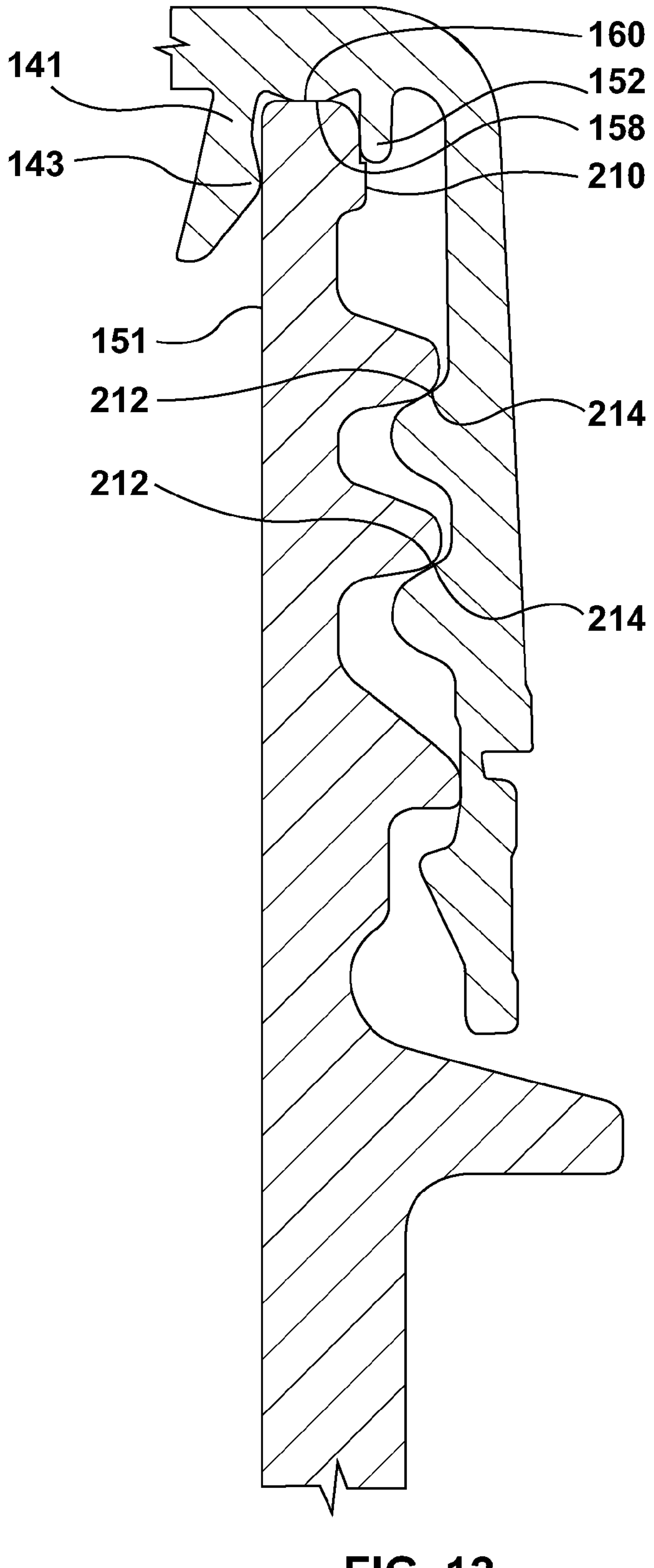


FIG. 12

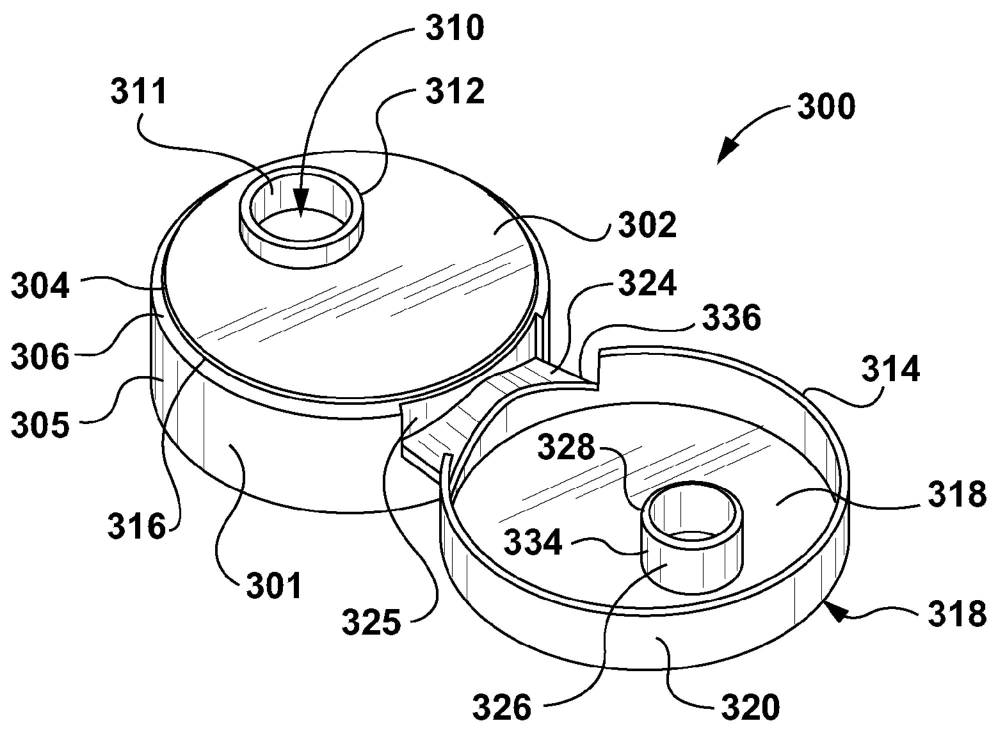

310
311
312
300
302
304
324
336
306
314
305
328
318
316
334
301
318
325
326
320

FIG. 13

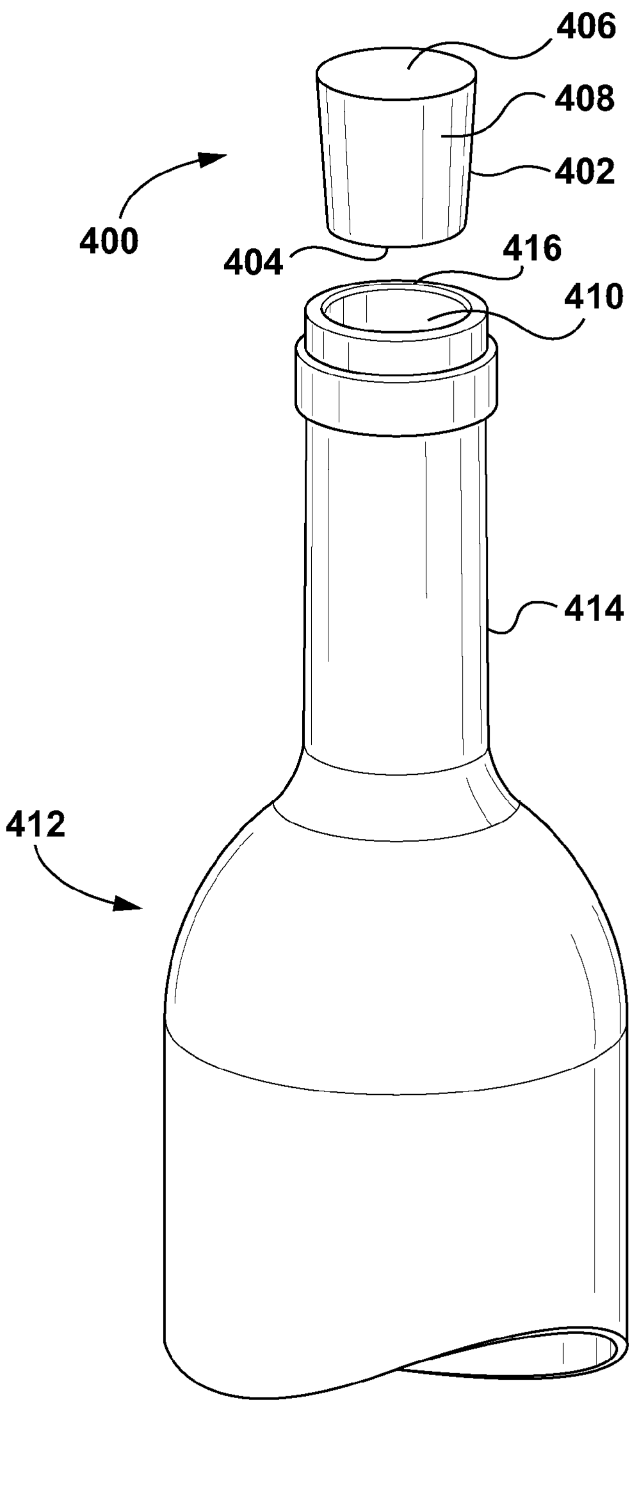


FIG. 14

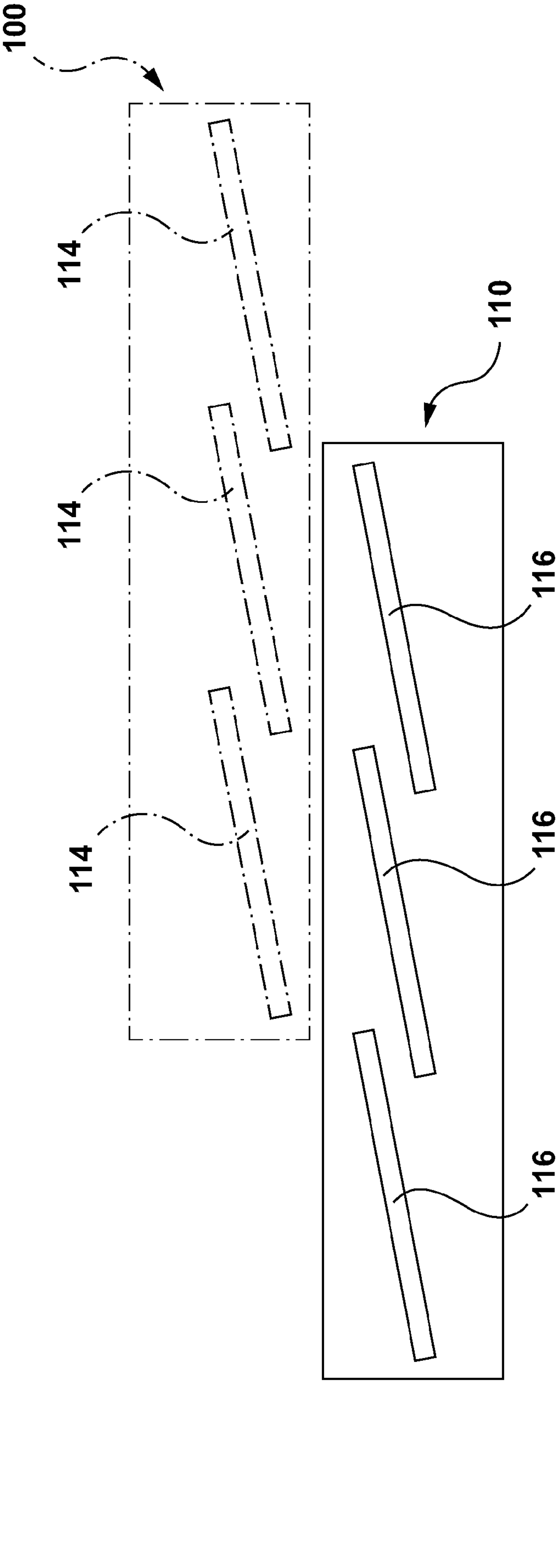


FIG. 15A

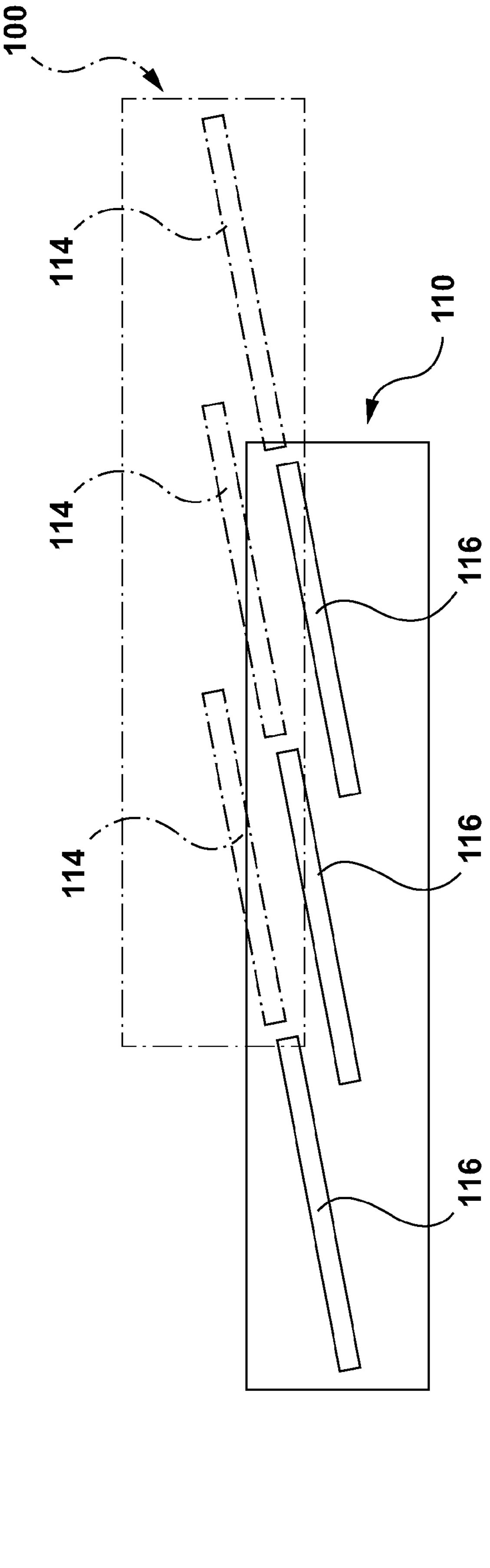


FIG. 15B

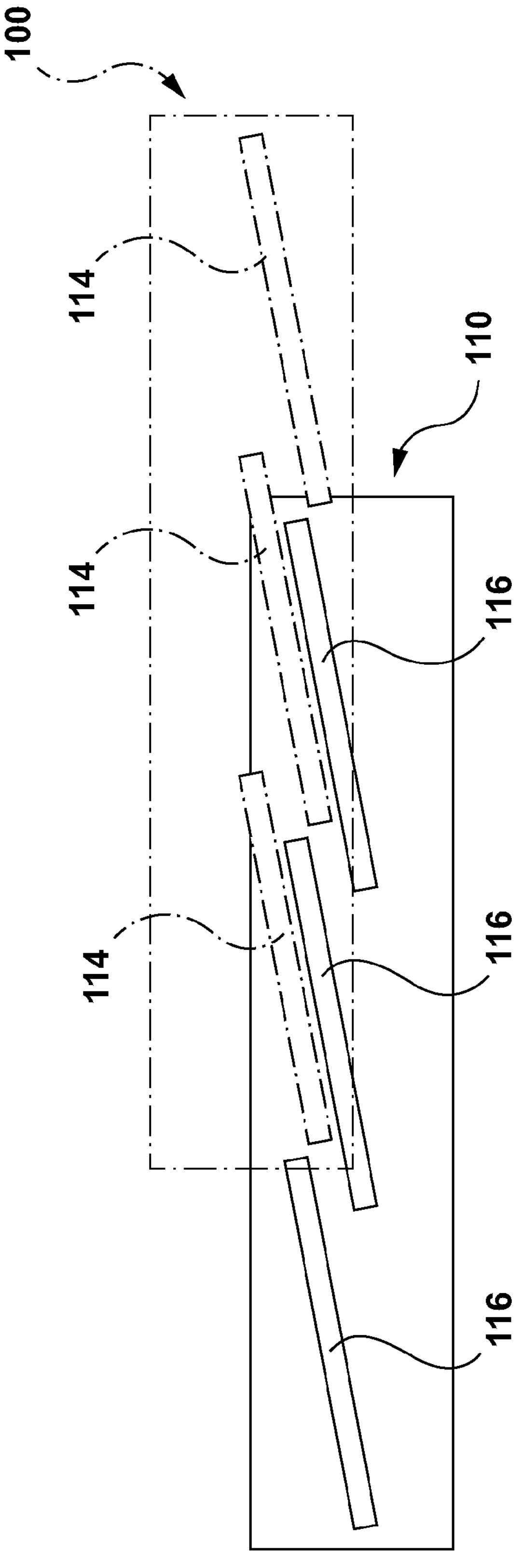


FIG. 15C

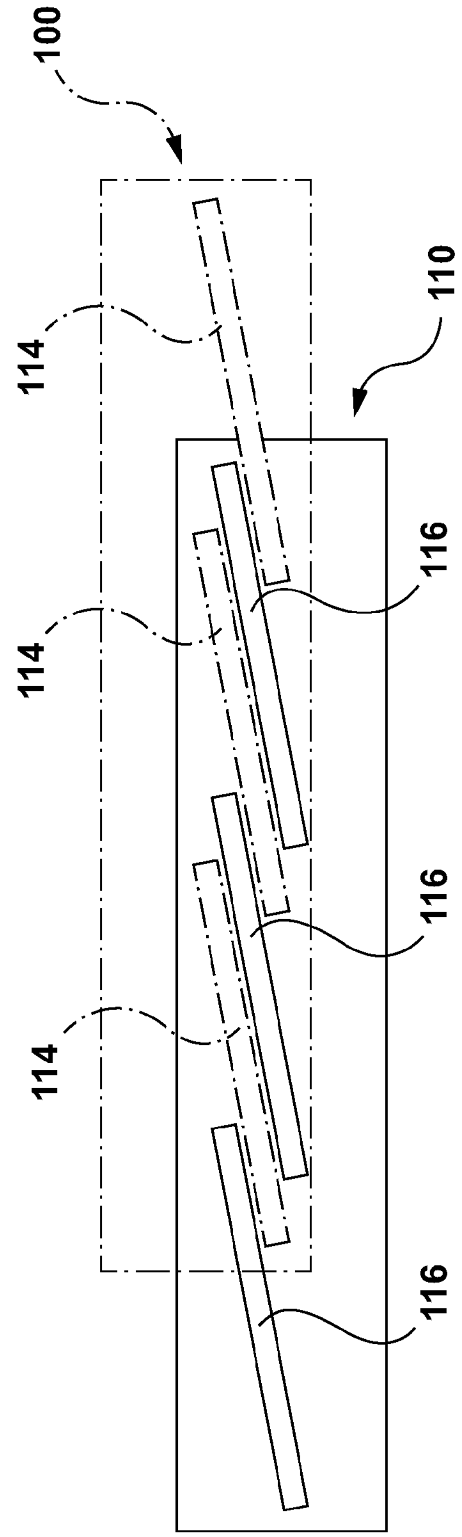


FIG. 15D

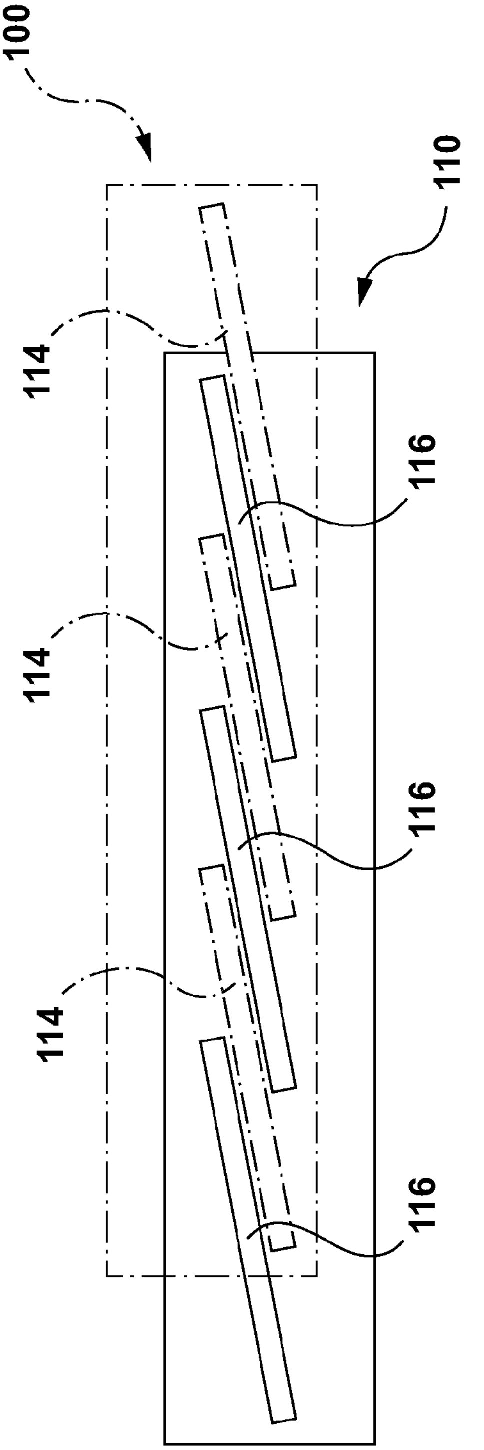


FIG. 15E

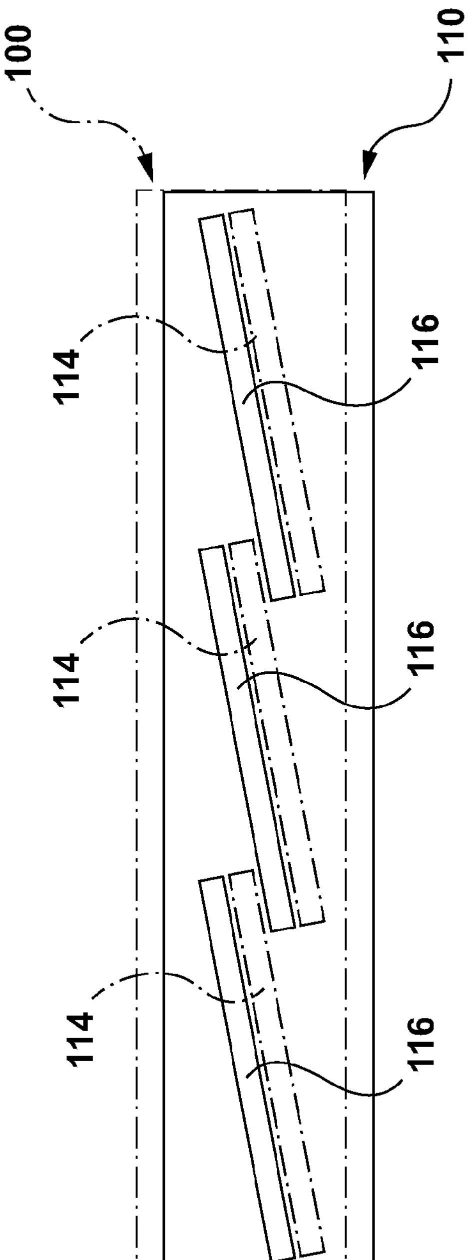


FIG. 15F

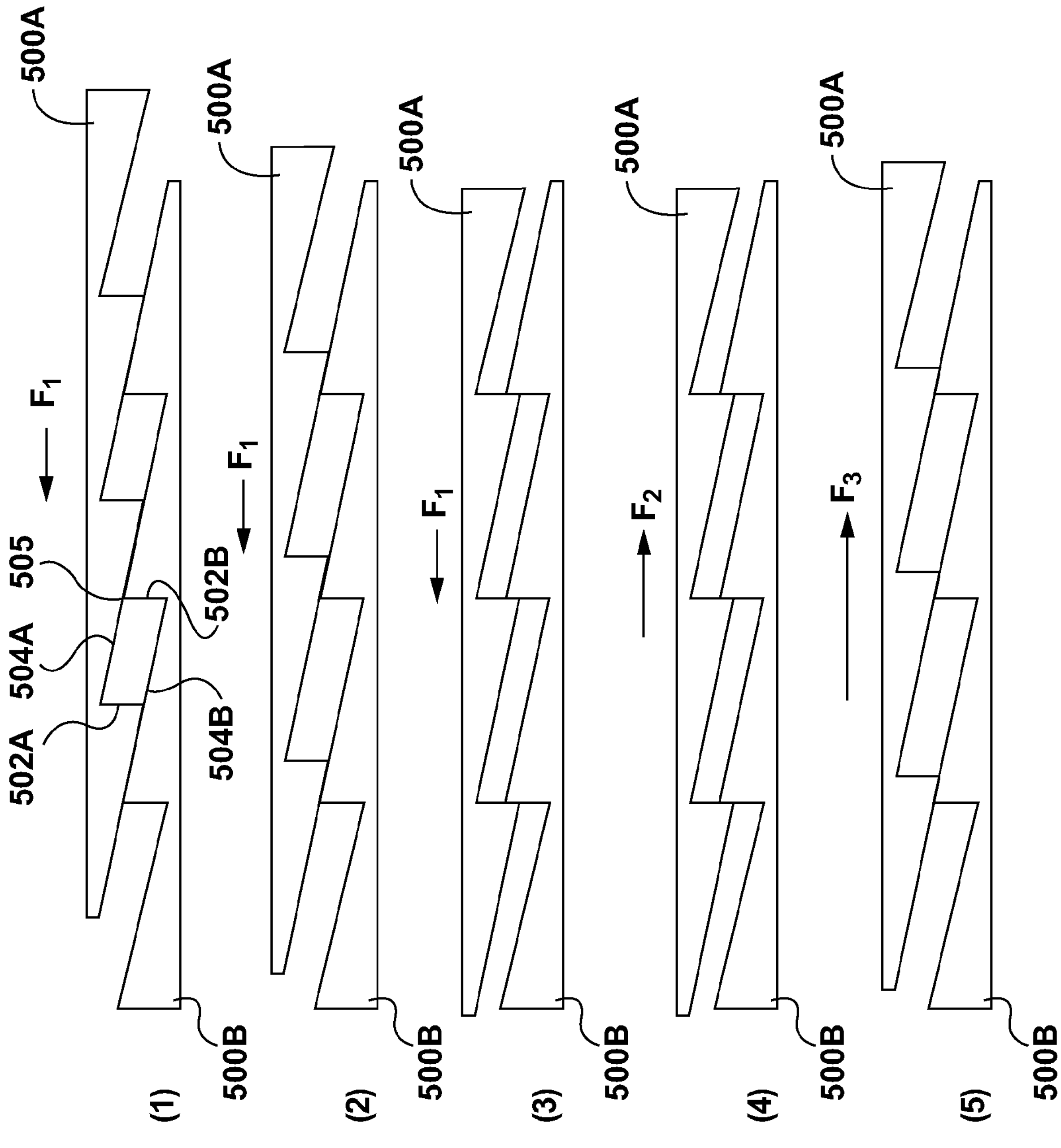


FIG. 16

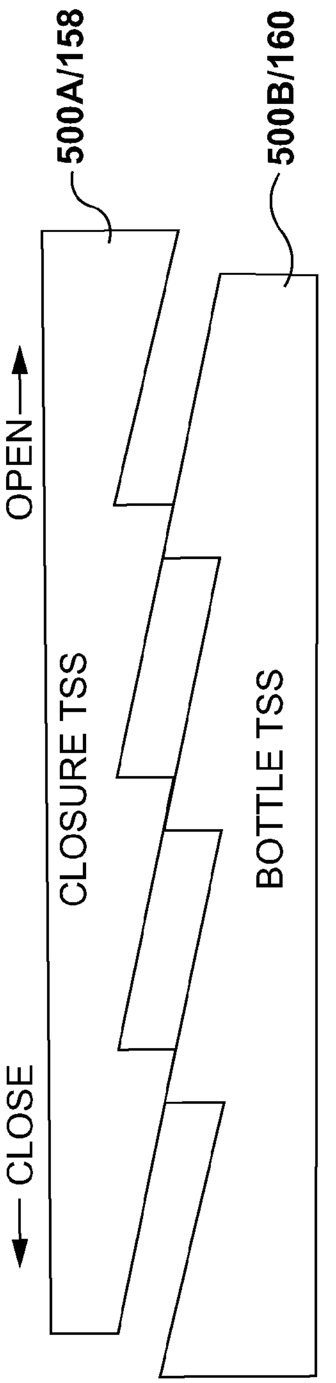


FIG. 17A

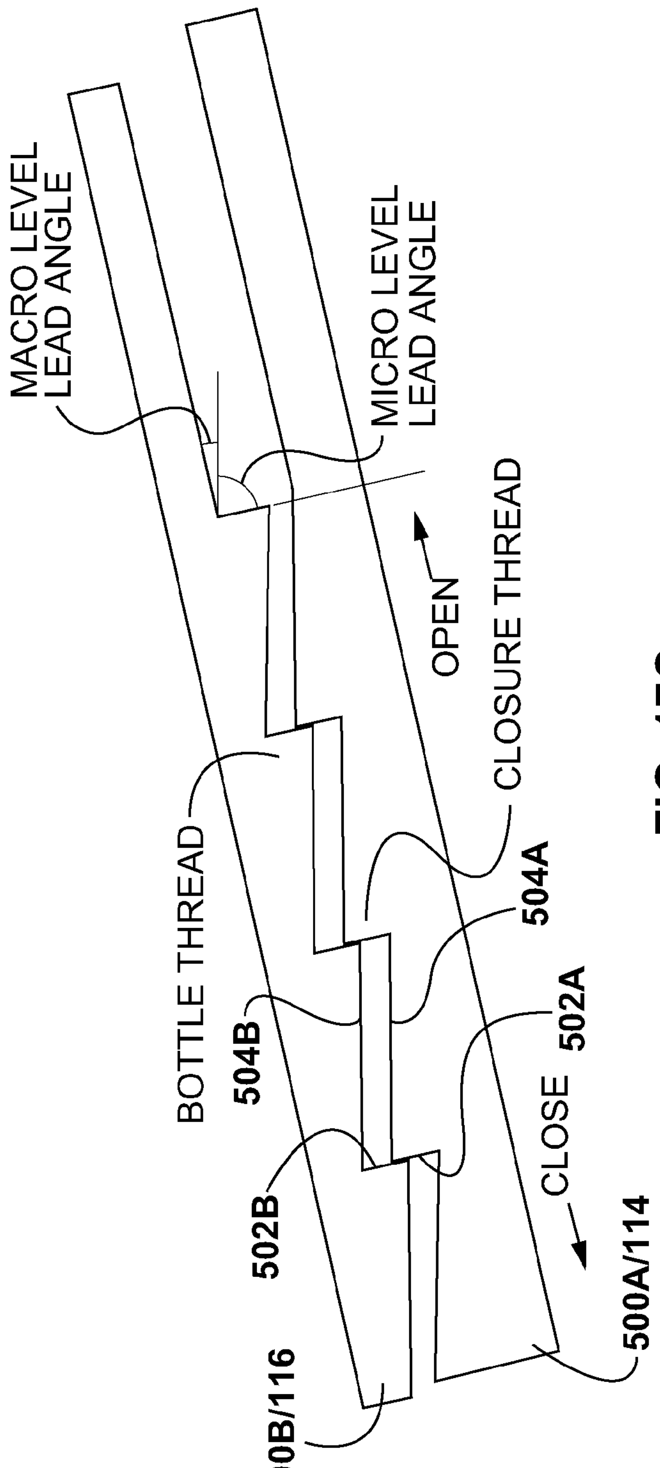


FIG. 17C

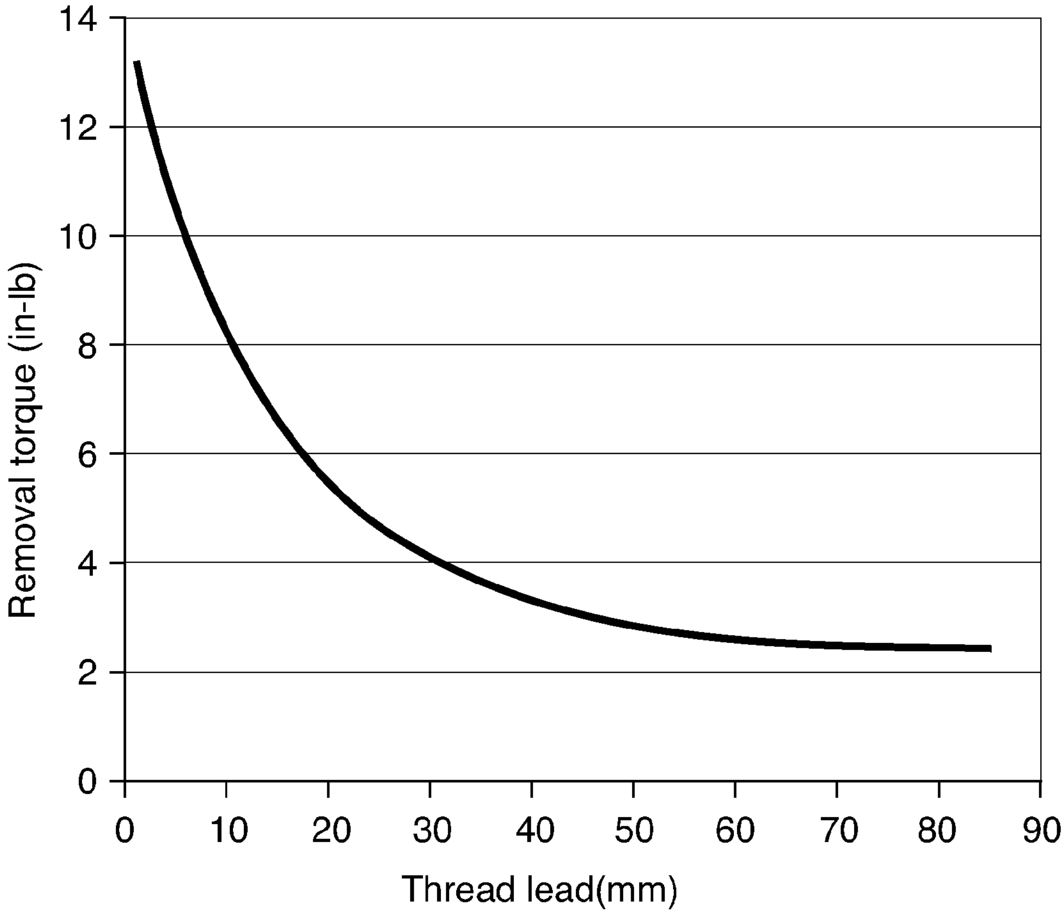

14
12
10
8
6
4
2
0
Removal torque (in-lb)
0
10
20
30
40
50
60
70
80
90
Thread lead(mm)

FIG. 17B

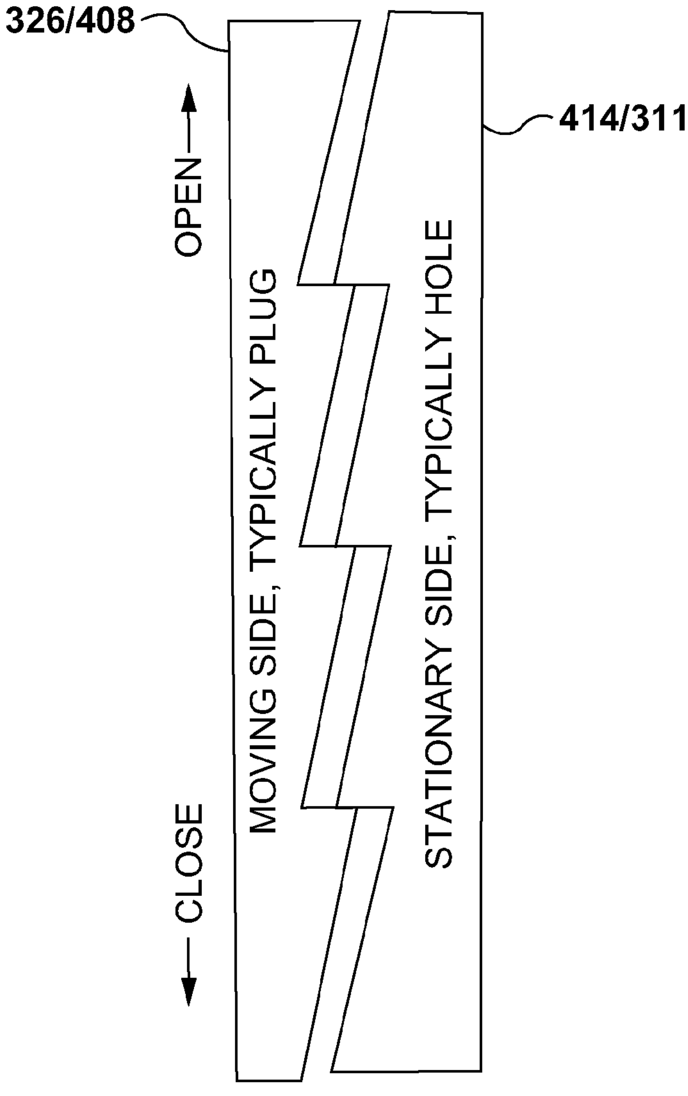

326/408
414/311
OPEN
CLOSE
MOVING SIDE, TYPICALLY PLUG
STATIONARY SIDE, TYPICALLY HOLE

FIG. 18

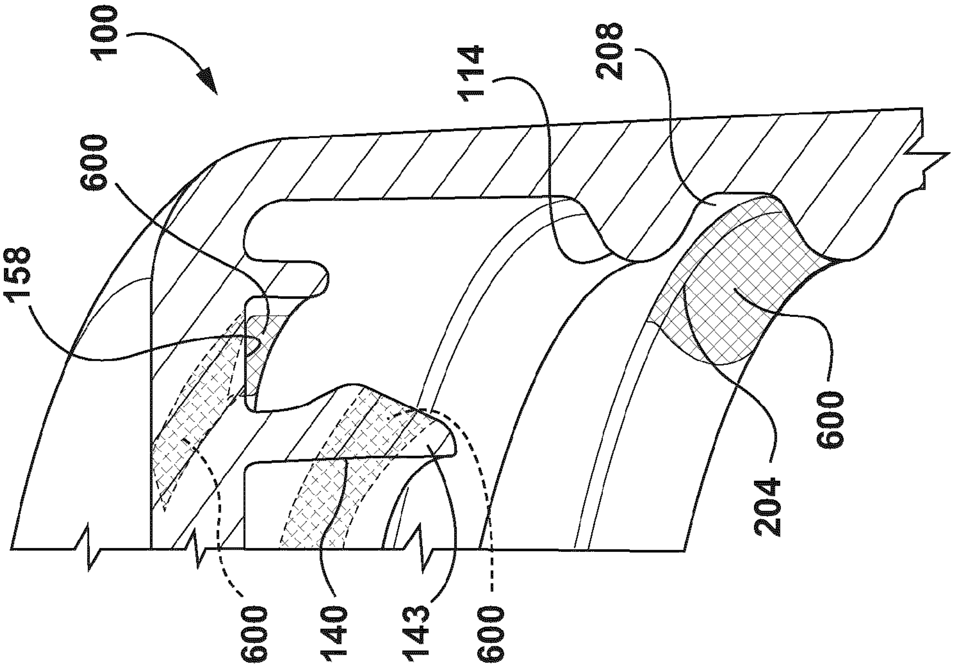

100
600
158
114
208
600
204
600
140
143
600

FIG. 20

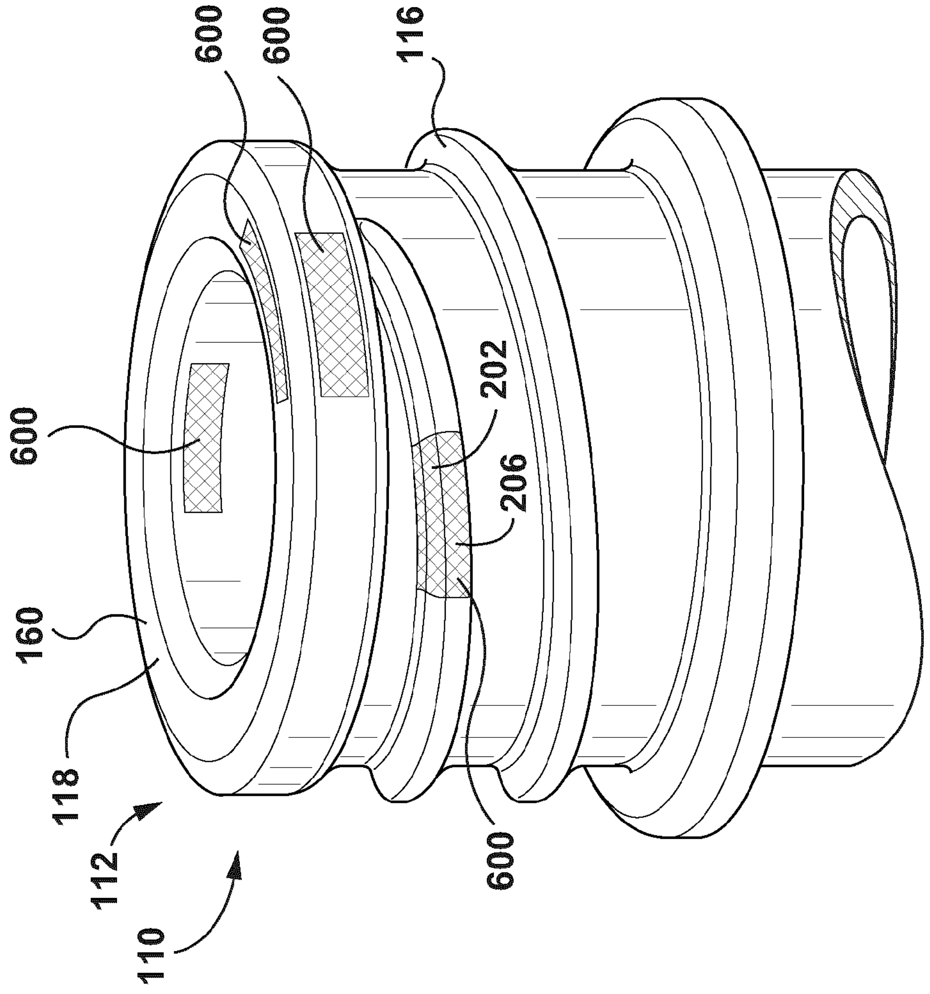

600
600
116
600
202
206
160
118
600
112
110

FIG. 19

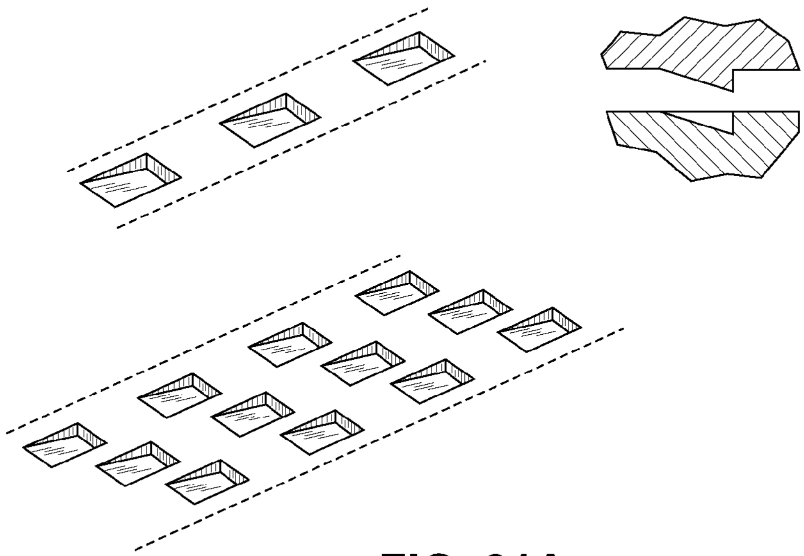


FIG. 21A

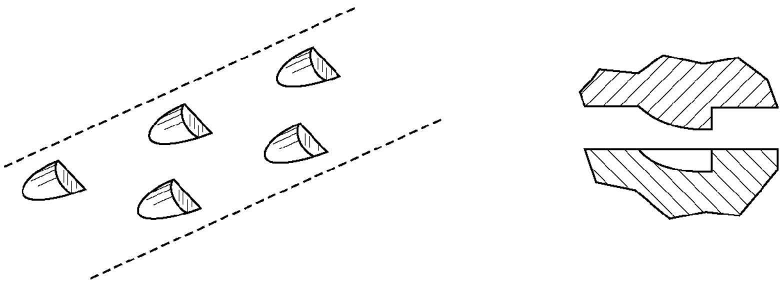


FIG. 21B

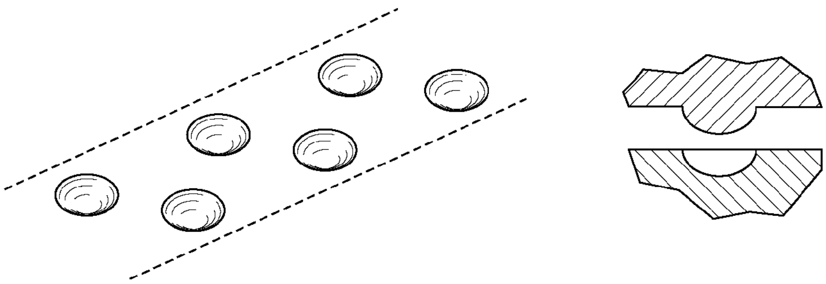


FIG. 21C

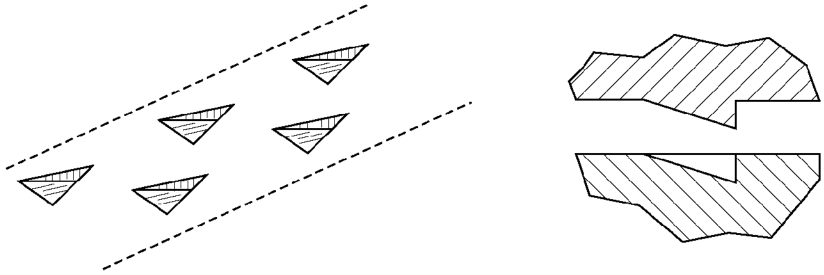


FIG. 21D

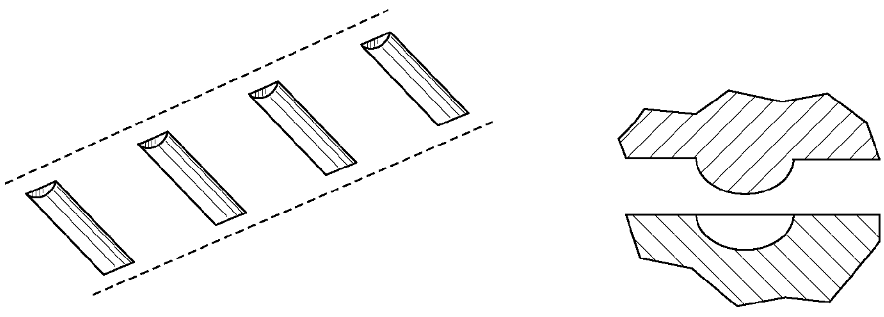


FIG. 21E

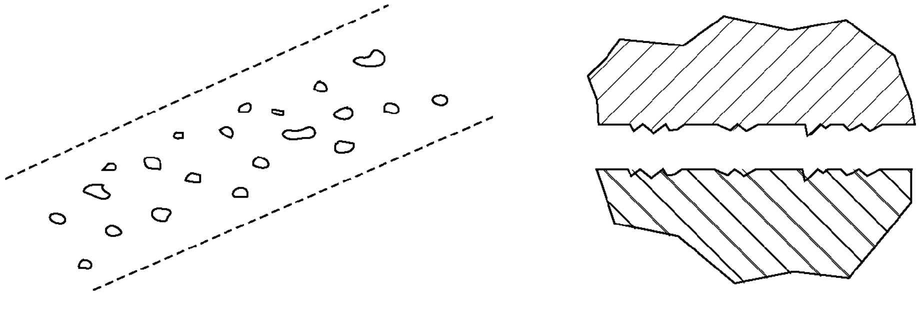


FIG. 21F

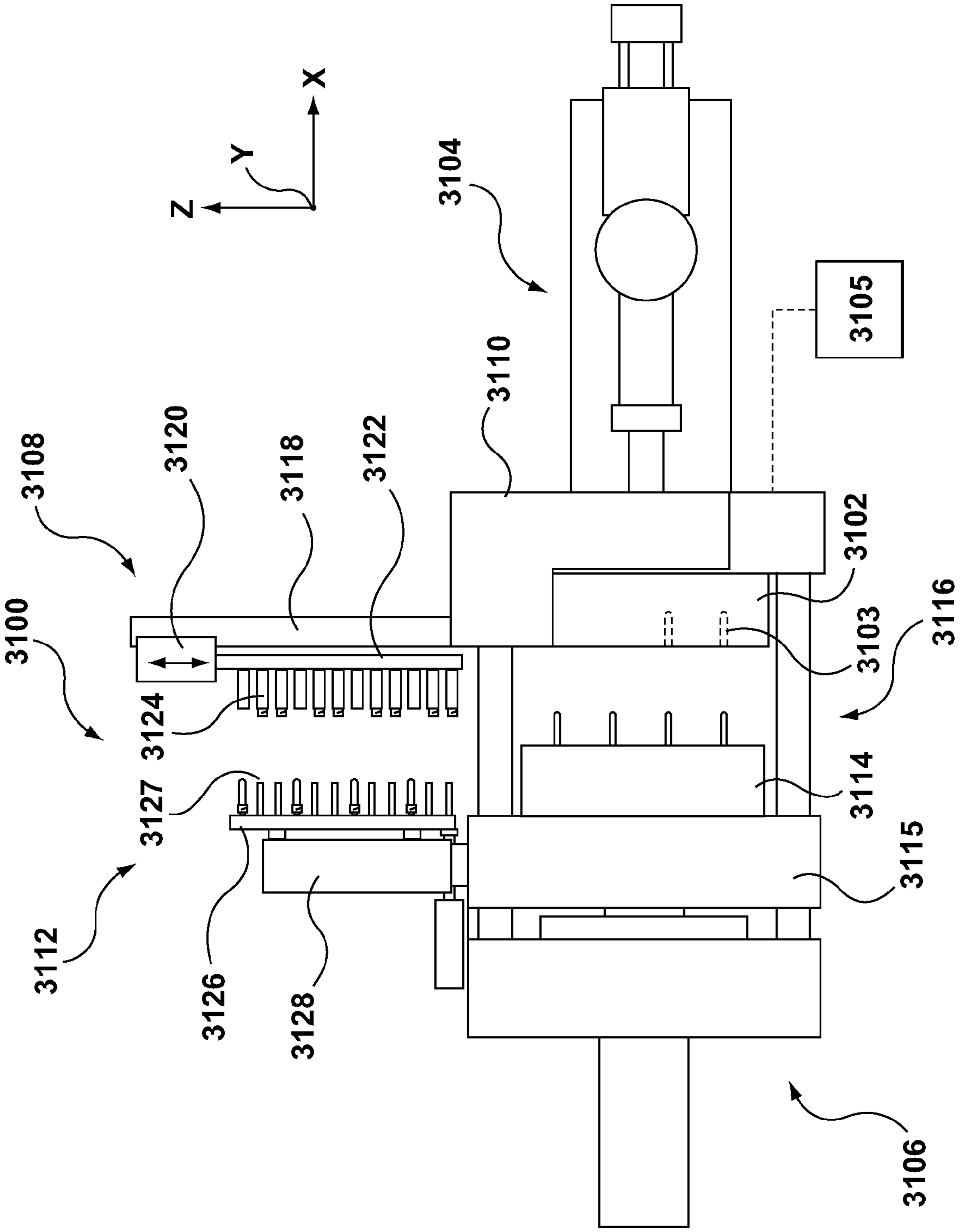

X
Y
Z
3104
3105
3110
3108
3120
3118
3122
3100
3124
3102
3103
3116
3114
3127
3112
3115
3126
3128
3106

FIG. 22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2016/051330

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***B65D 41/00*** (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: ***B65D 41/00*** (2006.01), ***B65D 41/34*** (2006.01), ***B65D 41/36*** (2006.01)

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Databases: Questel-Orbit, Canadian Patent Database.
Keywords: Contact surface force overcome micro-surface texture structure feature easy-glide glide locking removal torque predictable predetermined resistance open close opening closing saw-tooth stepped slope tread friction.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US7942287B2, (KING) 17 May 2011 (17-05-2011) *Whole Document*	1 – 64
X	US1882996A, (SCOFIELD) 18 October 1932 (18-10-1932) *Whole Document*	1 – 3, 6 – 12, 22, 26, 43, 44, 47, 48, 52, 53, 56 – 58, 60, 61
X	US1858826A, (HOLLAND) 17 May 1932 (17-05-1932) *Whole Document*	1 – 3, 6 – 12, 22, 26, 43, 44, 47, 48, 52, 53, 56 – 58, 60, 61
A	WO2016026035A1, (HYVARINEN et al.) 25 February 2016 (25-02-2016) *Whole Document*	1 – 64
A	US4809858A, (OCHS) 07 March 1989 (07-03-1989) *Whole Document*	1 – 64

☐ Further documents are listed in the continuation of Box C.

☑ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier application or patent but published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
02 February 2017 (02-02-2017)

Date of mailing of the international search report
02 February 2017 (02-02-2017)

Name and mailing address of the ISA/CA
Canadian Intellectual Property Office
Place du Portage I, C114 - 1st Floor, Box PCT
50 Victoria Street
Gatineau, Quebec K1A 0C9
Facsimile No.: 819-953-2476

Authorized officer

Tanya Hanham (819) 639-7854

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2016/051330

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US7942287B2	17 May 2011 (17-05-2011)	US2007144999A1	28 June 2007 (28-06-2007)
		AT441597T	15 September 2009 (15-09-2009)
		AU2004299319A1	30 June 2005 (30-06-2005)
		AU2004299319B2	30 September 2010 (30-09-2010)
		BRPI0417779A	20 March 2007 (20-03-2007)
		BRPI0417779B1	16 November 2016 (16-11-2016)
		CA2550617A1	30 June 2005 (30-06-2005)
		CA2550617C	18 September 2012 (18-09-2012)
		CN1894139A	10 January 2007 (10-01-2007)
		CN1894139B	03 August 2011 (03-08-2011)
		CY1110560T1	29 April 2015 (29-04-2015)
		DE602004022977D1	15 October 2009 (15-10-2009)
		DK1694575T3	02 November 2009 (02-11-2009)
		EP1694575A1	30 August 2006 (30-08-2006)
		EP1694575B1	02 September 2009 (02-09-2009)
		EP1694575B8	14 October 2009 (14-10-2009)
		ES2332179T3	28 January 2010 (28-01-2010)
		GB0329444D0	28 January 2004 (28-01-2004)
		GB2409200A	22 June 2005 (22-06-2005)
		GB2409200B	17 January 2007 (17-01-2007)
		HK1077554A1	18 May 2007 (18-05-2007)
		JP2007514619A	07 June 2007 (07-06-2007)
		JP4686476B2	25 May 2011 (25-05-2011)
		MXPA06006898A	04 September 2006 (04-09-2006)
		PT1694575E	06 October 2009 (06-10-2009)
		RU2006125732A	27 January 2008 (27-01-2008)
		RU2374155C2	27 November 2009 (27-11-2009)
		WO2005058720A1	30 June 2005 (30-06-2005)
US1882996A	18 October 1932 (18-10-1932)	None	
US1858826A	17 May 1932 (17-05-1932)	None	
WO2016026035A1	25 February 2016 (25-02-2016)	None	
US4809858A	07 March 1989 (07-03-1989)	US4809858A	07 March 1989 (07-03-1989)
		EP0312833A2	26 April 1989 (26-04-1989)