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(54) **A SEALING SYSTEM AND USE THEREOF, A KIT OF PARTS AND A METHOD OF ASSEMBLING THE KIT OF PARTS, AND A METHOD OF SEALING AN ITEM**

(57) A sealing system for tamper-proof sealing an item. The sealing system comprises: a housing (102, 104) enclosing an internal volume (116) and being provided with a transparent area (102b, 104b); a sealing wire fixedly positioned in the housing and forming a loop projecting from the housing, which loop is configured to seal the item; and a plurality of visually distinct elements (106) fixedly disposed in said internal volume and forming a pattern which is visually identifiable through the transparent area. The plurality of visually distinct elements are visually detectable from the outside of the seal and form a tamper-proof unique and random identifier which is destroyed when someone opens the housing.

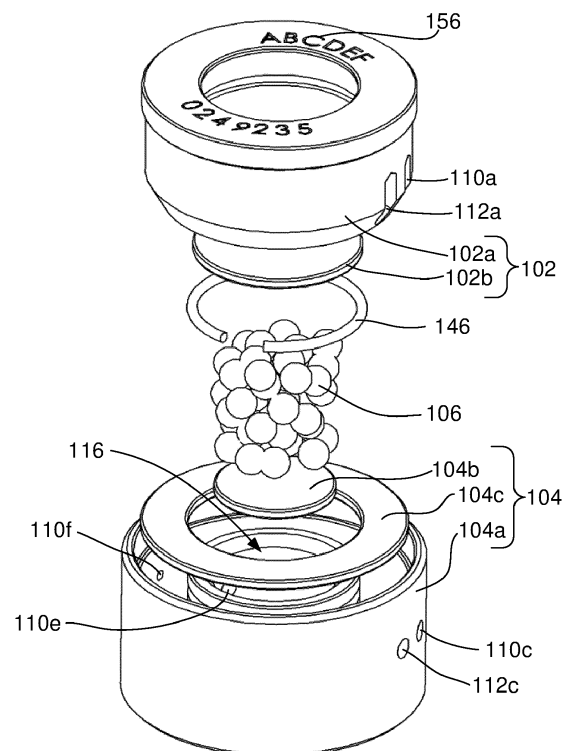


Fig. 8

Description

Technical field

[0001] The present invention relates to a sealing system for sealing an item, in particular for the purposes of tamper-proof marking the item to be identifiable over time. The present invention also relates to a use of the sealing system for sealing an item and to a method of sealing an item. The present invention further relates to a method of verifying a sealed item and to a verification device therefor. The present invention moreover relates to a kit of parts for assembling the sealing system and to a method of assembling the kit of parts.

Background art

[0002] A known type of sealing system used for marking an item to be identifiable over time is an "E-type seal", also known as a "copper-brass passive seal". Such a seal is used by the Energy XVII Directorate General (Euratom Safeguards) of Luxembourg and also by the International Atomic Energy Agency (IAEA) of Vienna in the context of nuclear materials which require high levels of safety for tracking and/or inspection. The E-type seal is used, a.o., in nuclear facilities to keep track of verified materials, freeze stock of nuclear material, protect equipment from unauthorized access, etc.

[0003] An example of a conventional E-type seal is described by reference to figures 1A to 3B. The seal comprises two housing members 2, 4, namely a copper housing member 2 and a brass housing member 4. Figure 1A shows the copper housing member 2 from the outside and figure 1B shows the same copper housing member 2 from the inside. Figure 2A shows the brass housing member 4 from the outside and figure 2B shows the same brass housing member 4 from the inside. The two housing members 2, 4 can be interlocked with one another to form a closed housing as shown in figures 3A and 3B. By design, the closed housing cannot be opened again without damaging the housing members 2, 4. The brass housing member 4 comprises two openings 10, 12 through which two ends of a sealing wire 14 are placed.

[0004] The identity of the E-type seal is obtained by using a drop of tin 6 which is placed inside the housing. The drop 6 is scratched in random manner (e.g. by an inspector applying the seal or during manufacture of the seal) so as to obtain a unique pattern 8. The sealing wire 14 (e.g. a one- or multi-stranded metallic or non-metallic wire) is used to connect together the item(s) that are to be sealed. For example, when sealing a door or a cupboard, the sealing wire 14 passes through the handles. The two ends of the sealing wire 14 are placed through the openings 10, 12 in the housing member 4 and are then knotted together. The housing members 2, 4 are then snap-fastened together in order to close the seal and thus preventing a third party from accessing the knot and untying the sealing wire 14. The closed seal together

with its sealing wire 14 is shown in figures 3A (copper side view) and 3B (brass side view).

[0005] The use of the seal is as follows. Before installing the seal, the identities of the two housing members are photographed and stored digitally in a database. In other words, the seal is archived. An identity number etched on (one or both of) the housing member(s) is also archived as the seal number and is associated with the stored photographs. During installation of the seal, its identity number may be correlated with various data such as date of installation, place, etc. In order to inspect the seal, a subsequent inspection is performed. An inspector cuts the cord 14 and takes the seal to analysis premises where it is cut open. Its two identities are photographed and correlated by optical superposition with the reference identities in the archive. In this manner it can be verified that the seal was not changed or tampered with since its installation.

[0006] While such a sealing system is low cost and simple to implement, inspection of the seals is quite involved. For example, it is not possible to inspect seal identity on site and in real time, which means that a seal that has already been installed needs to be replaced regularly in order for it to be inspected in the analysis premises. When inspection is performed, there is thus one seal which is being analyzed and another seal which has had to be installed to replace the seal being inspected. Furthermore, it is not possible to inspect a seal without removing it or damaging it meaning that each inspection requires a new seal to be installed.

Disclosure of the invention

[0007] According to an aspect of the present invention, a sealing system for sealing an item is proposed. The sealing system comprises: a housing including a first housing member and a second housing member, the housing enclosing an internal volume; interlocking means for interlocking the first housing member and the second housing member to form said housing; and a sealing wire comprising a first part and a second part, the first part of the sealing wire being fixedly positioned in said housing, the second part of the sealing wire forming a loop projecting from said housing, which loop is configured to seal said item, wherein the housing has at least one transparent area and wherein the sealing system further comprises a plurality of visually distinct elements fixedly disposed in said internal volume and forming a pattern which is visually identifiable through said at least one transparent area.

[0008] Similarly to the scratches in the drop of tin used in the known sealing system, the plurality of visually distinct elements forms a randomized unique identity for each seal. However, the plurality of visually distinct are visually detectable from the outside of the seal through the at least one transparent area provided in the housing. In other words, the seal identity can be checked without having to remove and open (and thereby damaging) the

housing. The seal can thus be inspected more easily. There is also no need to remove the seal and do the analysis in a dedicated headquarters. Rather, the inspector can take a photograph of the seal and the pattern obtained by the plurality of visually distinct elements and the photograph can be compared in real time to the stored images in the dedicated database.

[0009] Advantageously, the sealing system is also very resistant to tampering. First, the housing is designed to be damaged when it is opened thus preventing unauthorized access. Second, even if someone would be able to open and reclose the housing without damaging either of the housing members and/or other components, the plurality of visually distinct elements will have shifted during the opening and reclosing. The pattern will thus no longer match that in the dedicated database such that it will become clear on inspection that the sealing system has been tampered with. This tamper resistance is not feasible with the known E-type seal where the seal identity remains unchanged if someone would be able to open and reclose the copper-brass housing.

[0010] The use of a plurality of visually distinct elements for tamperproof storage of an item has been disclosed in R.G. Johnston and J.S. Warner, *Unconventional Security Devices*, Journal of Physical Security 7(3), 102-104 (2014) where an item to be protected was stored in a transparent box together with a multitude of coloured beads. After closing, digital photographs were taken and stored and any opening of the transparent box would lead to a shifting of the beads. In case of tampering, the initial photographs and the reclosed box have a different bead pattern.

[0011] In an embodiment of the present invention, said plurality of visually distinct elements are manufactured from an elastic material, in particular silicone rubber. This is advantageous as the elastic nature of the plurality of visually distinct elements allows them to be somewhat compressed inside the internal volume, which compression causes the plurality of visually distinct elements to be fixedly positioned. This is thus a convenient way to maintain pattern integrity. Silicone rubber is particularly advantageous for nuclear applications where high temperatures (up to and exceeding 150°C) and/or radiation may occur.

[0012] In an embodiment of the present invention, said plurality of visually distinct elements comprise differently coloured elements. Using colours allows to use identically shaped elements while still being visually distinguishable.

[0013] In an embodiment of the present invention, said plurality of visually distinct elements comprise spherical elements. The use of spherical elements results in a more random pattern of the elements when compared to cubic, rectangular, tetrahedron, etc. shaped elements as these elements tend to at least partially align along their flat surfaces.

[0014] In an embodiment of the present invention, the interlocking means comprise: a first groove provided on

the first housing member; a second groove provided on the second housing member, the first and the second groove forming an annular channel within the housing; and an annular fixation element disposed in said annular channel. In this embodiment, the interlocking means are inaccessible from the outside of the housing (i.e. the annular channel is present inside the housing) which improves the robustness and anti-tamper properties of the sealing system.

[0015] In an embodiment of the present invention, the interlocking means comprise: one or more first elements integrally formed with the first housing member; and one or more second elements integrally formed with the second housing member, the first and second elements at least partially contacting one another to interlock the housing members. Such interlocking means are especially suited in case the housing members are made, in particular injection moulded, from a plastic material. Typically, the first and/or second elements are slightly elastic and are deformed during closing of the housing members when they pass along one another and then reform (e.g. expand) thereby interlocking the housing members. Moreover, these elements may also be formed to be inaccessible from the outside of the housing which improves the robustness and anti-tamper properties of the sealing system.

[0016] In an embodiment of the present invention, said first housing member comprises a transparent cover disk and a casing having a top end and a bottom end, the transparent cover disk closing the top end of the casing and forming at least part of said at least one transparent area, and said second housing member comprises a double-walled casing having an outer wall, an inner wall and a bottom wall connecting the inner wall and the outer wall, the casing being at least partially positioned in the double-walled casing with the bottom end of the casing facing the bottom wall of the double-walled casing. The use of glass cover for the top end of the first housing maximizes the area for visual inspection of the internal volume. Furthermore, the use of a double-walled casing causes the housing to comprise three parallel walls compared to the required minimum number of two walls (i.e. both housing members being one-walled). This adds an additional physical protection layer for the internal volume thus improving strength, rigidity, robustness, etc. Moreover, this allows bending the sealing wire in a U-shaped form at each opposing end of the housing thereby causing an increase in the force required to pull the sealing wire from the housing.

[0017] In an embodiment of the present invention, the first part of the sealing wire is nipped between said first housing member and said second housing member. By nipping the sealing wire between the housing members, the sealing wire is fixed to the housing and cannot be removed therefrom without reopening the housing. Moreover, there is no need to knot the sealing wire in order to fix this, thereby simplifying the placement of the sealing system.

[0018] In an embodiment of the present invention, said housing comprises a sleeve region, a top region and a bottom region, the second part of the sealing wire projecting from the sleeve region. In this embodiment, the sealing wire is inserted into the housing via the sleeve region and is thus inserted in a direction that is substantially perpendicular to the closing direction of the housing (i.e. pressing the housing members towards one another). There is thus no interference between the various motions required to assemble the sealing system.

[0019] In an embodiment of the present invention, the housing comprises at least one further transparent area which allows visual inspection of at least part of the first part of the sealing wire. In this way sealing wire integrity can be checked without having to open the housing and damage the sealing system.

[0020] According to an aspect of the present invention, a use of the sealing system as described above for tamper-proof sealing an item is proposed. The use has the same advantages as the sealing system already described above.

[0021] According to an aspect of the present invention, a kit of parts for assembling the sealing system as described above is proposed. The kit of parts comprises: the first housing member, the second housing member, the sealing wire, the plurality of visually distinct elements, and a guide insert configured for guiding the sealing wire, wherein the first housing member and the second housing member are mounted on one another in a first position to form a first housing enclosing a first internal volume with the guide insert extending through at least part of the first housing member and the second housing member and with the plurality of visually distinct elements being disposed in said first internal volume.

[0022] The kit of parts has the same advantages as the sealing system already described above. The guide insert also has several advantages. First, as the guide insert extends through at least part of the first housing member and the second housing member, the guide insert acts as a temporary attachment element to attach the housing members together. In other words, even before placement, the housing members are held together and the plurality of visually distinct elements are already disposed in the housing. This also results in a fast placement of the sealing system as the housing (with the plurality of visually distinct elements) are already pre-assembled. Second, the guide insert provides for a fast, easy and correct placement of the sealing wire as compared to a kit of parts without the guide insert where the inspector would have to guide the sealing wire through the internal structure of the housing members. This would be difficult and cumbersome as not all of the internal structure is necessarily visible from the outside.

[0023] In an embodiment of the present invention, the interlocking means comprise: a first groove provided on the first housing member; a second groove provided on the second housing member, the first groove and the second groove not being aligned when the housing mem-

bers are in their first position; and an annular fixation element disposed in said second groove, the annular fixation element urging against the first housing member when the housing members are in their first position. In this embodiment, the interlocking means are pre-assembled and allow for an easy and rapid sealing of the housing. The housing is, in particular, sealed by pushing the housing members together until the first and second groove align which allows the annular fixation element to expand or contract into the first groove. The annular fixation element is then disposed in part in both grooves and prevents the housing members from being pulled apart. Moreover, the interlocking means are inaccessible from the outside of the housing (i.e. the annular channel formed by the aligned grooves is present inside the housing) which improves the robustness and anti-tamper properties of the sealing system.

[0024] According to an aspect of the present invention, a method of assembling the kit of parts as described above is proposed. The method comprises: looping the sealing wire around an item; guiding part of the sealing wire through the guide insert; removing the guide insert; and interlocking the interlocking means thereby sealing part of the sealing wire in the housing. Interlocking the interlocking means preferably comprises: pushing the first housing member and the second housing member towards one another thereby aligning the first and second groove and allowing the annular fixation element to at least partially move into the first groove. As already described above, the kit of parts allows for a fast, easy and correct assembly of the seal. This is also reflected in the method of assembling the kit of parts to form the sealing system which requires only very few steps, which are moreover easy to execute.

[0025] According to an aspect of the present invention, a verification device for verifying the sealing system as described above is proposed. The verification device comprises: an imaging device for generating at least one image of said pattern; and communication means for sending said at least one image to an external server and for receiving a verification message from said external server or a memory for storing at least one historic image of said pattern and a processor configured for determining whether or not the pattern included in said at least one image corresponds to that in said at least one historic image. The verification device allows for a real-time inspection of the sealing system integrity without requiring a destruction of the sealing system.

[0026] According to an aspect of the present invention, a method of sealing an item is proposed. The method comprises: looping a sealing wire around said item; guiding the ends of said sealing wire through a housing, the housing comprising an internal volume with a plurality of visually distinct elements fixedly disposed therein and forming a pattern which is visually identifiable through at least one transparent area provided in the housing; and sealing said housing. The method has the same advantages as the sealing system already described above.

[0027] In an embodiment of the present invention, the method further comprises providing said housing including a first housing member and a second housing member which are mounted on one another in a first position enclosing a first internal volume with a plurality of visually distinct elements disposed therein, and wherein sealing said housing comprises pushing the first housing member towards the second housing member thereby interlocking said housing members and fixing said pattern. Sealing the housing by pushing the housing members together offers a fast, easy and reliable way to achieve the required sealed housing. Moreover, the pushed together housing members will also nip part of the sealing wire between the housing members thus preventing the sealing wire from being removed from the housing.

[0028] In an embodiment of the present invention, the method further comprises: generating at least one image of said pattern; and storing said at least one image, and optionally an unique identifier, on a server. In this embodiment, each sealing system is archived on a server. This is very advantageous for later inspection.

[0029] According to an aspect of the present invention, a method of verifying a sealed item is proposed. The method comprises: providing the sealed item with the item having being sealed and archived as described above; generating at least one further image of said pattern; sending said at least one further image to said server; comparing said at least one further image to said at least one image stored on the server; and determining whether or not the pattern formed by the plurality of visually distinct elements in said at least one further image corresponds to that in said at least one image stored on the server. The method has the same advantages as the verification device already described above.

Brief description of the drawings

[0030] The invention will be further explained by means of the following description and the appended figures.

Figures 1A to 2B represent various parts of a prior art E-type seal.

Figures 3A and 3B represent a known E-type seal in its closed position together with a sealing wire.

Figures 4A, 4B, 4C and 4D show a perspective, top, bottom and cross-sectional view of a sealing system according to the present invention.

Figure 5 shows a detail of figure 4D.

Figure 6A and 6B show a perspective and cross-sectional view of a kit of parts for assembling the sealing system shown in figure 4A.

Figure 7 shows a detail of figure 6B.

Figure 8 shows an exploded view of the kit of parts of figure 6A without the sealing wire.

Figures 9A, 9B and 9C shows a perspective top and bottom view and a cross-sectional view of the casing of the first housing member used in the sealing system shown in figure 4A.

Figures 10A, 10B and 10C shows a perspective top and bottom view and a cross-sectional view of the casing of the second housing member used in the sealing system shown in figure 4A.

Description of the invention

[0031] The present invention will be described with respect to particular embodiments and with reference to certain drawings but the invention is not limited thereto but only by the claims. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes. The dimensions and the relative dimensions do not necessarily correspond to actual reductions to practice of the invention.

[0032] Furthermore, the terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. The terms are interchangeable under appropriate circumstances and the embodiments of the invention can operate in other sequences than described or illustrated herein.

[0033] Moreover, the terms top, bottom, over, under and the like in the description and the claims are used for descriptive purposes. The terms so used are interchangeable under appropriate circumstances and the embodiments of the invention described herein can operate in other orientations than described or illustrated herein.

[0034] Furthermore, the various embodiments, although referred to as "preferred" are to be construed as exemplary manners in which the invention may be implemented rather than as limiting the scope of the invention.

[0035] The term "substantially", as used when referring to a measurable value such as a parameter, a quantity, a duration, and so on, is intended to include variations of +/- 10% or less, preferably +/- 5% or less, more preferably +/- 1% or less, and even more preferably +/- 0.1% or less, of and from the specified value to the extent that the variations apply to function in the disclosed invention. It should be understood that the term "substantially A" is intended to include "A".

[0036] An embodiment of a sealing system 100 according to the present invention is described by reference to figures 4A to 10C. The sealing system 100 is shown in figures 4A to 5 in its applied state and is shown in figures 6A to 7 in its pre-assembled state (i.e. as a kit of parts 150).

[0037] The sealing system 100 comprises a first housing member 102 and a second housing member 104 which are interlocked with one another to form a closed housing 105. The interlocking of the housing members 102, 104 will be described below with reference to figures 5 and 7. The housing 105 is preferably designed to be resistant to non-destructive disassembly, i.e. under pre-

ferred circumstances, the housing 105 cannot be disassembled without damaging one or more components of the sealing system 100. The housing 105 encloses an internal volume 116 which is best shown in figure 8.

[0038] Each housing member 102, 104 comprises a substantially cylindrical casing 102a, 104a which is closed off at one end by an optically transparent disk and/or ring 102b, 104b, 104c as shown in figure 8. In this context, optically transparent is intended to mean that the disk and/or ring transmits nearly all of the visible light; for example transmits at least 90% of the visible light or scatters at most 10% of the visible light; preferably transmits at least 95% of the visible light or scatters at most 5% of the visible light; more preferably transmits at least 98% of the visible light or scatters at most 2% of the visible light; more preferably transmits at least 99% of the visible light transmitted or scatters at most 1% of the visible light. In the illustrated embodiment, each optically transparent disk and/or ring 102b, 104b, 104c is formed from glass which is beneficial for nuclear applications and where temperatures may reach up to and exceeding 150°C. However, it will be readily appreciated that other materials may be used to manufacture these disks and/or ring 102b, 104b, 104c, e.g. a plastic material. The disks 102b, 104b allow for a visual inspection of the internal volume 116 enclosed by the housing 105, while the ring 104b allows for a visual inspection of a sealing wire 114. In other words, the disks 102b, 104b form at least one (two in the illustrated embodiment) transparent area of the housing 105.

[0039] The substantially cylindrical casings 102a, 104a are illustrated in detail in figures 9A to 10C. The cylindrical casing 102a of the first housing member 102 is shown in figures 9A to 9C and comprises a wall 120 having an outer face 120a and an inner face 120b. The casing 102a has a top end 122 and a bottom end 124. Near the top end 122, an inner collar 126 (or a flange) is provided which acts as a supporting surface for the glass disk 102b. In the illustrated embodiment, the glass disk 102b is inserted from the bottom end 124 of the cylindrical casing 102a and rests against the bottom surface of the inner collar 126. If desired, adhesive means (e.g. glue) may be used to fix the glass disk 102b is fixed to the inner collar 126. However, such adhesion is not required as the glass disk 102b may also be pushed against the inner collar 126 due to a plurality of visually distinct elements 106 present in the internal volume 116 as described below. The main advantage of this embodiment is that the glass disk 102b is not removable without unlocking the housing 105, thus improving the robustness and/or anti-tamper properties of the sealing system 100.

[0040] In an alternative non-illustrated embodiment, the glass disk 102b is inserted into the cylindrical casing 102a via the top end 122 thereof and is fixed to the top surface of the inner collar 126. The glass disk 102b may be fixed to the inner collar 126, e.g. by means of glue.

[0041] The cylindrical casing 104a of the second housing member 104 comprises a double-wall structure hav-

ing a U-shaped cross-section as shown in figure 10C. The cylindrical casing 104a comprises an outer wall 128 and an inner wall 130, each wall 128, 130 having an outer face 128a, 130a and an inner face 128b, 130b. The walls 128, 130 are connected by a bottom wall 132 having a top face 132a and a bottom face 132b. The internal volume 116 of the housing 105 is delimited by the inner face 130b of the inner wall 130 of the cylindrical casing 104a. The casing 104a has a top end 134 and a bottom end 136. Near the bottom end 136, an inner collar 138 is provided which acts as a supporting surface for the glass disk 104b. In particular, the inner collar 138 is formed at least in part by the bottom wall 132. In the illustrated embodiment, the glass disk 104b is inserted into the cylindrical casing 104a via the top end 136 thereof and is fixed to the top surface of the inner collar 138. The glass disk 104b may be fixed to the inner collar 138, e.g. by means of glue. The bottom wall 132 is also provided with two openings 140 the function of which is described below with respect to figure 4C. These openings 140 are also covered by a glass annular ring 104c which rests on the top surface 132a of the bottom wall 132. As with the first housing member 102, the main advantage of this embodiment is that the glass elements 104b, 104c are not removable without unlocking the housing 105, thus improving the robustness and/or anti-tamper properties of the sealing system 100.

[0042] It will be readily appreciated that, in other embodiments, the functionality of the glass disk 104b and the glass annular ring 104c may be combined by a single glass disk that is fixed to the bottom face 132b of the bottom wall 132 of the casing 104a.

[0043] The cylindrical casing 120a is designed in order to at least partially fit within the space created between the walls 128, 130 of the cylindrical casing 104a. For the purposes of interlocking the housing members 102, 104, each cylindrical casing 102a, 104a is provided with a groove 142, 144. Groove 142 is provided on the inner face 120b of the wall 120 of the cylindrical casing 102a and groove 144 is provided on the outer face 130a of the inner wall 130 of the cylindrical casing 104a. It will be readily appreciated that the grooves 142, 144 could also be provided in other faces and/or walls of the casings 102a, 104a as long as they are able to be aligned with and positioned adjacent one another upon assembly of the housing members 102, 104.

[0044] It will be readily appreciated that the cylindrical casing 104a of the second housing member 104 could also be formed as a single wall structure similar to the cylindrical casing 102a.

[0045] In order for the sealing wire 114 to extend through the housing 105, there are provided openings for placement of the sealing wire 114. More specifically, there are two openings 110a, 110b through opposing sides of the wall 120 with one of end of the sealing wire 114 passing therethrough; there are two openings 112a, 112b through opposing sides of the wall 120 with the other of end of the sealing wire 114 passing therethrough;

there are two openings 110c, 110f through opposing sides of the outer wall 128 with one of end of the sealing wire 114 passing therethrough; there are two openings 110d, 110e through opposing sides of the inner wall 130 with said one of end of the sealing wire 114 passing therethrough; there are two openings 112c, 112f through opposing sides of the outer wall 128 with the other of end of the sealing wire 114 passing therethrough; and there are two openings 112d, 112e through opposing sides of the inner wall 130 with said other of end of the sealing wire 114 passing therethrough.

[0046] In the illustrated embodiments, the substantially cylindrical casings 102a, 104a are manufactured from anodized aluminium. Aluminium is advantageous for its low weight, low cost and high strength. Anodizing the aluminium is preferred as this allows for an easier detection of attempted tampering (e.g. trying to force open the housing). However, it will be readily appreciated that other materials may be used to manufacture these substantially cylindrical casings 102a, 104a.

[0047] It will be readily appreciated that the housing members 102, 104 may have a different shape besides the illustrated substantially cylindrical design. In general, a horizontal cross-section through the housing members 102, 104 can have any two-dimensional shape, such as a circle, triangle, square, rectangle, ellipsoid, etc.

[0048] The sealing system 100 further comprises a plurality of visually distinct elements 106 disposed in the internal volume 116. The function thereof will be described below with respect to figures 4A to 4D. However, the assembly of the sealing system 100 will be described further. In a first stage, the cylindrical casings 102a, 104a are manufactured and the disks 102b, 104b are attached thereto. In a second stage, an annular ring element 146 is placed in either one of the grooves 142, 144 and the plurality of visually distinct elements 106 are placed in the internal volume 116. The housing members 102, 104 are then placed in one another and pushed together until the openings 110a, 110b, 112a, 112b are aligned with the openings 110c-f, 112c-f and a guide insert 148 is placed through at least part of the aligned openings. The guide insert 148 keeps the housing members 102, 104 together. This assembly set-up is illustrated in figures 6A to 6C and forms, together with the sealing wire 114, the kit of parts 150 from which the sealing system 100 is to be assembled.

[0049] The annular ring element 146 is a snap ring which is under tension in the kit of parts 150. In the illustrated embodiment, the ring element 146 is positioned in groove 144 and urges against the inner face 120b of the wall 120 of the first housing 102 as shown in figure 7. Naturally, the mechanical inversion is also possible with the ring element 146 being positioned in groove 142. It will be readily appreciated that the ring element 146 need not be a continuous ring, but may be only part of a ring. Furthermore, the ring element 146 could also be replaced with one or more other interlocking means (e.g. a tooth and groove, elastic snap members, etc.) that are inte-

grally formed on the housing members 102, 104. Such interlocking means are especially suited in case the housing members 102, 104 are made, in particular injection moulded, from a plastic material.

[0050] The guide insert 148 comprises two hollow tubes 148a, one for each end of the sealing wire 114, with a handle part 148b on the end thereof. The handle part 148b ensures a correct positioning of the guide insert 148 as this abuts against the outer face 128a of the outer wall 128 of the second housing member 104 and allows for an easier handling of the narrow hollow tubes 148a. In the kit of parts 150, the plurality of visually distinct elements 106 are free to move around in the internal volume.

[0051] In order to seal an item (not shown), the sealing wire 114 is looped around the item (see figures 3A and 3B) to form a loop portion 114a and both ends of the sealing wire 114 are inserted through the guide insert 148 as shown in figures 6A to 6C. Once the ends of the sealing wire 114 are fully through the guide insert 148, the guide insert 148 is removed and the housing members 102, 104 are pushed together. This causes the part 114a of the sealing wire 114 which extends between the housing members 102, 104 to be bent and nipped therebetween as shown in figure 4D thus preventing the sealing wire 114 from being pulled from the housing 105. The movement directions of inserting the sealing wire 114 and closing the housing 105 are orthogonal so that these motions do not interfere with one another. Moreover, having the sealing wire 114 protruding from the outer face 128a of the housing 105, means that the top and bottom surface (i.e. the disks 102b, 104b) are fully available to push the housing members 102, 104 together which is not the case for the known E-type seal. Moreover, the sealing wire 114 does not appear in the field-of-view of the glass disks 102b, 104b, i.e. the view of the plurality of visually distinct elements 106 is not hampered by the sealing wire 114.

[0052] In an embodiment, a force of at least 200N, preferably 250N and more preferably 300N is required to pull the sealing wire 114 from the closed housing 105. Such a force prevents accidentally pulling out the sealing wire 114.

[0053] The openings 140 in the bottom wall 132 of the second housing member 104 allow for a visual inspection of the sealing wire 114 in the housing 105 as shown in figure 4C. This can be used to check sealing wire integrity and/or the correct placement thereof.

[0054] The housing members 102, 104 are pushed together until the grooves 142, 144 align thereby forming an annular channel 152 and allowing the ring element 146 to expand into the groove 142 as shown in figure 5. The expanding ring element 146 locks the housing members 102, 104 together and forming the housing 105 of the sealing system 100.

[0055] In the illustrated embodiment of the sealing system 100, the plurality of visually distinct elements 106 are elastic. This allows the plurality of visually distinct

elements 106 to be compressed somewhat upon pushing the housing members 102, 104 together, which compression fixes the plurality of visually distinct elements 106 in the internal volume 116. In other words, the plurality of visually distinct elements 106 cannot move once the sealing system 100 has been sealed. The elasticity may be achieved through various ways, e.g. the shape of the elements. However, in the illustrated embodiment, this is achieved due the material from which the plurality of visually distinct elements 106 are manufactured, namely silicone rubber. In particular, the silicone rubber (or in general the elements 106) has a Young's Modulus above 1 MPa, preferably above 3 MPa and more preferably above 5 MPa. In particular, the silicone rubber has a Young's Modulus below 50 MPa, preferably below 30 MPa and more preferably below 10 MPa. Most preferably the silicone rubber has a Young's Modulus of about 7 MPa. It has been found out that this allows the required compression of the plurality of visually distinct elements 106 while keeping the force required to push the housing members 102, 104 together relatively low. Silicone rubber is also advantageous for its resistance to radiation and/or high temperatures (150°C and higher) which may occur in nuclear applications.

[0056] In an embodiment, the force required to push the housing members 102, 104 together is less than 125N, preferably less than 100N and more preferably less than 75N. This allows for closing by hand such that no dedicated tools are required.

[0057] Once the sealing system 100 is sealed, the plurality of visually distinct elements 106 are fixed and the pattern 108 as observable through the glass disks 102b, 104b cannot be changed. The aim of the plurality of visually distinct elements 106 is to have a unique (or at least random) pattern 108 as observed through the glass disks 102b, 104b. An efficient and simple way of having visually distinct elements 106 is to use different coloured elements. It will naturally be appreciated that not all elements 106 have to be of different colour. Moreover, also visually transparent or translucent elements 106 may be used. If desired, also differently shaped elements 106 may be used to arrive at visually distinguishable patterns 108. Multi-coloured elements 106 are also possible and/or patterned elements 106 (e.g. having a flecked or spotted appearance).

[0058] In the illustrated embodiment, spherical elements 106 are used. Although other volumetric shapes are possible, it has been found that spherical elements 106 are better suited to provide a so random pattern 108 as possible. The dimensions of the spheres are all the same in the illustrated embodiment and are generally in the range of 1mm to 7mm and may be equal to 2mm, 3mm, 4mm, 5mm or 6mm. However, differently sized elements 106 are possible as well. In general, the size of the spheres (and of the elements 106 in general) depends on the overall size and design of the sealing system 100. The elements 106 need to be small enough to reliably generate a random pattern (i.e. they need to be able to

shift around when the sealing system 100 is not sealed) but they cannot get stuck or pass through cavities and/or openings in the housing interior.

[0059] In a non-illustrated embodiment of the sealing system, the plurality of visually distinct elements 106 are rigid, i.e. not elastic and an elastic element (e.g. a rubber block) is positioned within the internal volume 116. Upon pushing the housing members 102, 104 together, the elastic element is compressed and the force exerted from the compressed elastic element onto the plurality of visually distinct rigid elements 106 fixes them in place.

[0060] Once the sealing system 100 has been placed, the archiving is done. More specifically, one or more images are generated (e.g. by a digital camera) of the sealing system 100 or at least from the pattern 108 formed by the plurality of visually distinct elements 106 as seen through one or both of the transparent disks 102b, 104b. Preferably, the serial number 154 (or other identifier) of the sealing system 100 is also included in the images. All images and, optionally, installation related data, are stored on a server.

[0061] Using a verification device (not shown), an inspector can verify the sealing system 100 in real time without requiring a destruction of the sealing system. The verification device includes an imaging device (e.g. a camera) for generating at least one image of the sealing system 100, i.e. at least the pattern formed by the plurality of visually distinct elements 106 as seen through one or both of the transparent disks 102b, 104b. The verification device further includes communication means for sending said at least one image to an external server. At the external server, the received images are compared to the archived images. If the images match, a positive verification message is generated and transmitted, otherwise a negative verification message is generated and transmitted. The communication means in the verification device are configured for receiving the verification message from said external server.

[0062] Alternatively, the verification device includes a memory for storing at least one historic image of said pattern, i.e. for storing the archived data of the seal (or seals) to be inspected that day. The verification done by the external server is then done by the verification device in real time by its own processor and a verification message is generated and/or displayed.

[0063] In an embodiment, the image comparison includes intrinsic pattern feature estimation. This may include estimating the size, position and/or colour of the plurality of visually distinct elements 106 visible through the one or more transparent areas of the housing 105. This may also include, for the illustrated embodiment of the sealing system 100, estimation of the degree of compression of the plurality of visually distinct elements 106 against the flat disks 102b, 104b.

[0064] In an embodiment, the verification process occurring at the external server or in the verification device may include determining the seal serial number which is engraved on the housing 105. The verification process

may further include checking sealing wire integrity via the openings 140. These optional steps further automate the verification process thereby decreasing time required and/or reducing the risk of human error.

[0065] Although aspects of the present disclosure have been described with respect to specific embodiments, it will be readily appreciated that these aspects may be implemented in other forms within the scope of the invention as defined by the claims.

Claims

1. A sealing system (100) for sealing an item, the sealing system comprising:

- a housing (105) including a first housing member (102) and a second housing member (104), the housing enclosing an internal volume (116);
- interlocking means for interlocking the first housing member and the second housing member to form said housing; and
- a sealing wire (114) comprising a first part (114a) and a second part (114b), the first part of the sealing wire being fixedly positioned in said housing, the second part of the sealing wire forming a loop projecting from said housing, which loop is configured to seal said item,

characterized in that the housing has at least one transparent area and **in that** the sealing system further comprises a plurality of visually distinct elements (106) fixedly disposed in said internal volume and forming a pattern which is visually identifiable through said at least one transparent area.

2. The sealing system according to claim 1, wherein said plurality of visually distinct elements (106) are manufactured from an elastic material, in particular silicone rubber.
3. The sealing system according to claim 1 or 2, wherein said plurality of visually distinct elements (106) comprise differently coloured elements.
4. The sealing system according to any one of the preceding claims, wherein the interlocking means comprise:
 - a first groove (142) provided on the first housing member;
 - a second groove (144) provided on the second housing member, the first and the second groove forming an annular channel (152) within the housing; and
 - an annular fixation element (146) disposed in said annular channel,
 and/or

- one or more first elements integrally formed with the first housing member; and
- one or more second elements integrally formed with the second housing member, the first and second elements at least partially contacting one another to interlock the housing members.

5. The sealing system according to any one of the preceding claims, wherein said first housing member comprises a transparent cover disk (102b) and a casing (102a) having a top end (124) and a bottom end (122), the transparent cover disk closing the top end of the casing and forming at least part of said at least one transparent area, and wherein said second housing member comprises a double-walled casing having an outer wall (128), an inner wall (130) and a bottom wall (132) connecting the inner wall and the outer wall, the casing being at least partially positioned in the double-walled casing with the bottom end of the casing facing the bottom wall of the double-walled casing.
6. The sealing system according to any one of the preceding claims, wherein the first part of the sealing wire is nipped between said first housing member and said second housing member; and/or wherein said housing comprises a sleeve region (128a), a top region and a bottom region, the second part of the sealing wire projecting from the sleeve region.
7. The sealing system according to any one of the preceding claims, wherein the housing comprises at least one further transparent area (140) which allows visual inspection of at least part of the first part of the sealing wire.
8. Use of the sealing system according to any one of the preceding claims for tamper-proof sealing of an item.
9. A kit of parts (150) for assembling the sealing system according to any one of the claims 1 to 7, wherein the kit of parts comprises: the first housing member (102), the second housing member (104), the sealing wire (114), the plurality of visually distinct elements (106), and a guide insert (148) configured for guiding the sealing wire, wherein the first housing member and the second housing member are mounted on one another in a first position to form a first housing enclosing a first internal volume with the guide insert extending through at least part of the first housing member and the second housing member and with the plurality of visually distinct elements being disposed in said first internal volume.
10. The kit of parts according to claim 9, wherein the

interlocking means comprise:

- a first groove (142) provided on the first housing member;
- a second groove (144) provided on the second housing member, the first groove and the second groove not being aligned when the housing members are in their first position; and
- an annular fixation element (146) disposed in said second groove, the annular fixation element urging against the first housing member when the housing members are in their first position.

11. A method of assembling the kit of parts according to claim 9 or 10, the method comprising:

- looping the sealing wire (114) around an item;
- guiding part of the sealing wire through the guide insert (148);
- removing the guide insert; and
- interlocking the interlocking means thereby sealing part of the sealing wire in the housing (105).

12. The method of claim 11 for assembling the kit of parts according to claim 10, wherein interlocking the interlocking means comprises: pushing the first housing member (102) and the second housing member (104) towards one another thereby aligning the first groove (142) and second groove (144) and allowing the annular fixation element (106) to at least partially move into the first groove.

13. A verification device for verifying the sealing system according to any one of the claims 1 to 7, the verification device comprising:

- an imaging device for generating at least one image of said pattern; and
- communication means for sending said at least one image to an external server and for receiving a verification message from said external server, or
- a memory for storing at least one historic image of said pattern and a processor configured for determining whether or not the pattern included in said at least one image corresponds to that in said at least one historic image.

14. A method of sealing an item, the method comprising:

- looping a sealing wire (114) around said item;
- guiding the ends of said sealing wire through a housing (105), the housing comprising an internal volume (116) with a plurality of visually distinct elements (106) fixedly disposed therein and forming a pattern which is visually identi-

- able through at least one transparent area provided in the housing; and
- sealing said housing.

15. The method according to claim 14, wherein the method further comprises providing said housing including a first housing member (102) and a second housing member (104) which are mounted on one another in a first position enclosing a first internal volume with the plurality of visually distinct elements disposed therein, and wherein sealing said housing comprises pushing the first housing member towards the second housing member thereby interlocking said housing members and fixing said pattern.

16. The method according to claim 14 or 15, wherein the method further comprises:

- generating at least one image of said pattern; and
- storing said at least one image, and optionally a unique identifier, on a server.

17. A method of verifying a sealed item, the method comprising:

- providing the sealed item with the item having being sealed according to the method of claim 16;
- generating at least one further image of said pattern;
- sending said at least one further image to said server;
- comparing said at least one further image to said at least one image stored on the server; and
- determining whether or not the pattern formed by the plurality of visually distinct elements in said at least one further image corresponds to that in said at least one image stored on the server.

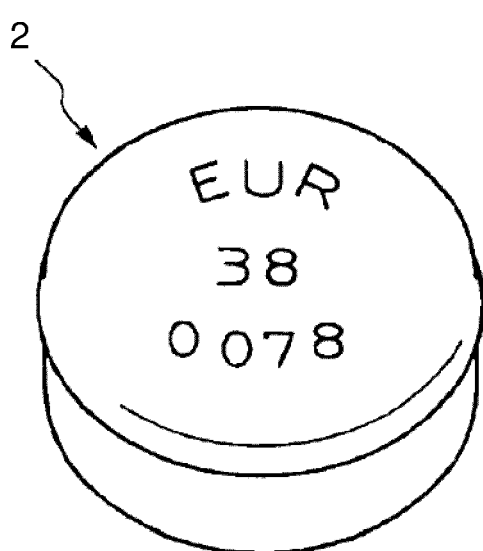


Fig. 1A
PRIOR ART

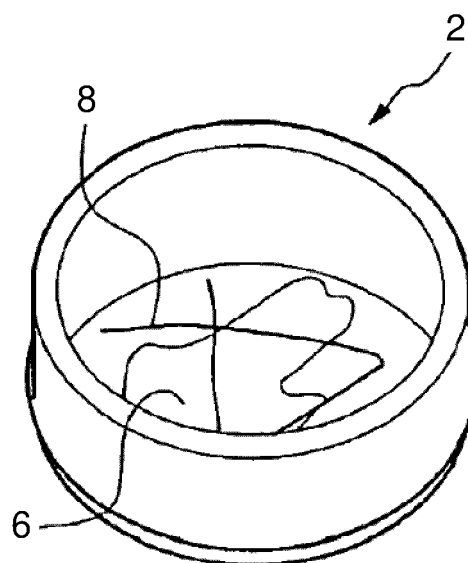


Fig. 1B
PRIOR ART

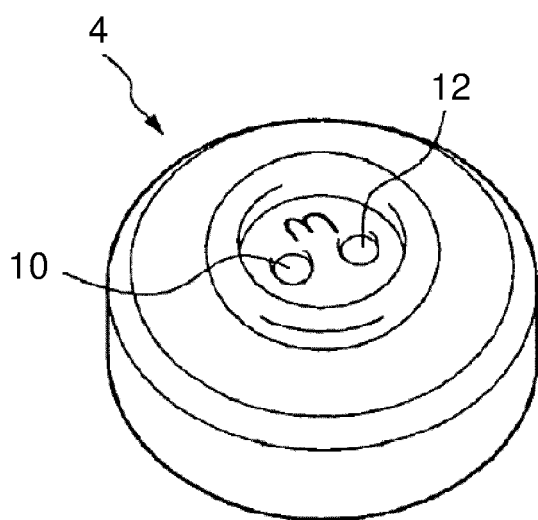


Fig. 2A
PRIOR ART

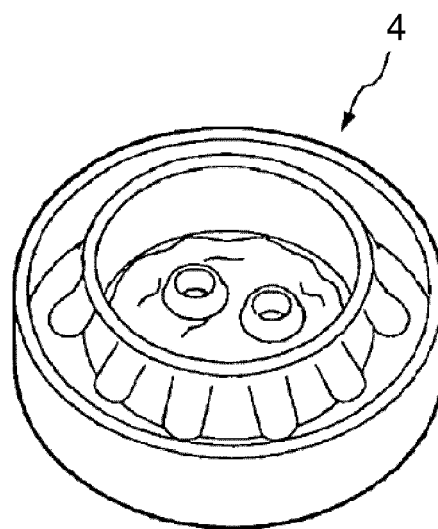


Fig. 2B
PRIOR ART

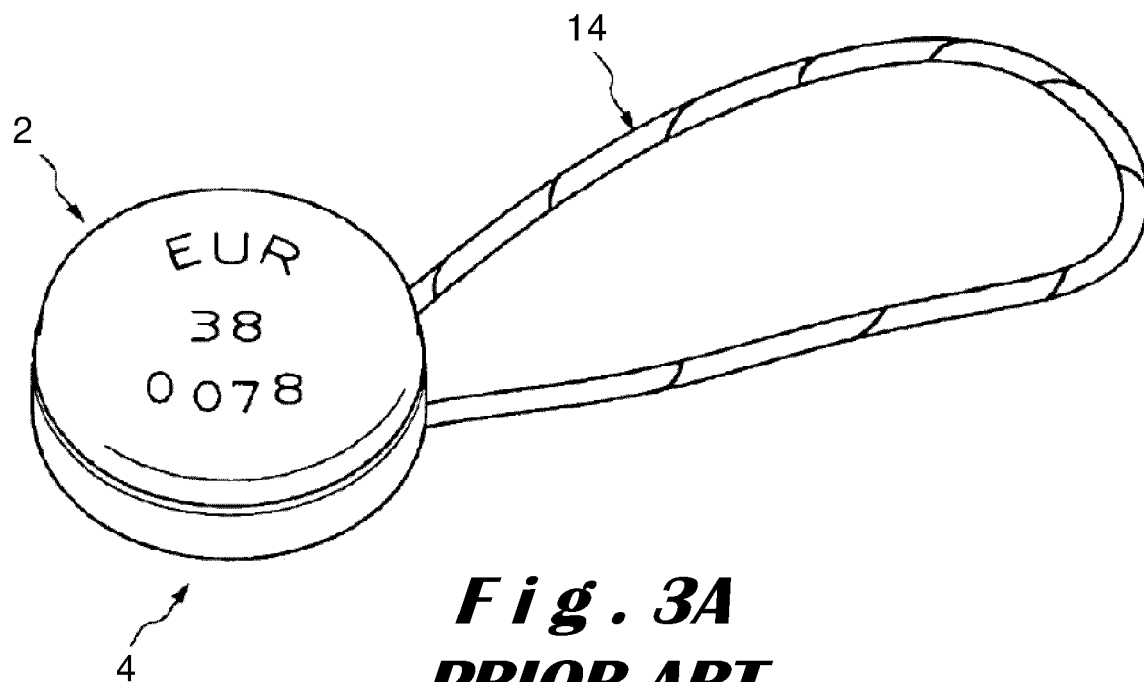


Fig. 3A
PRIOR ART

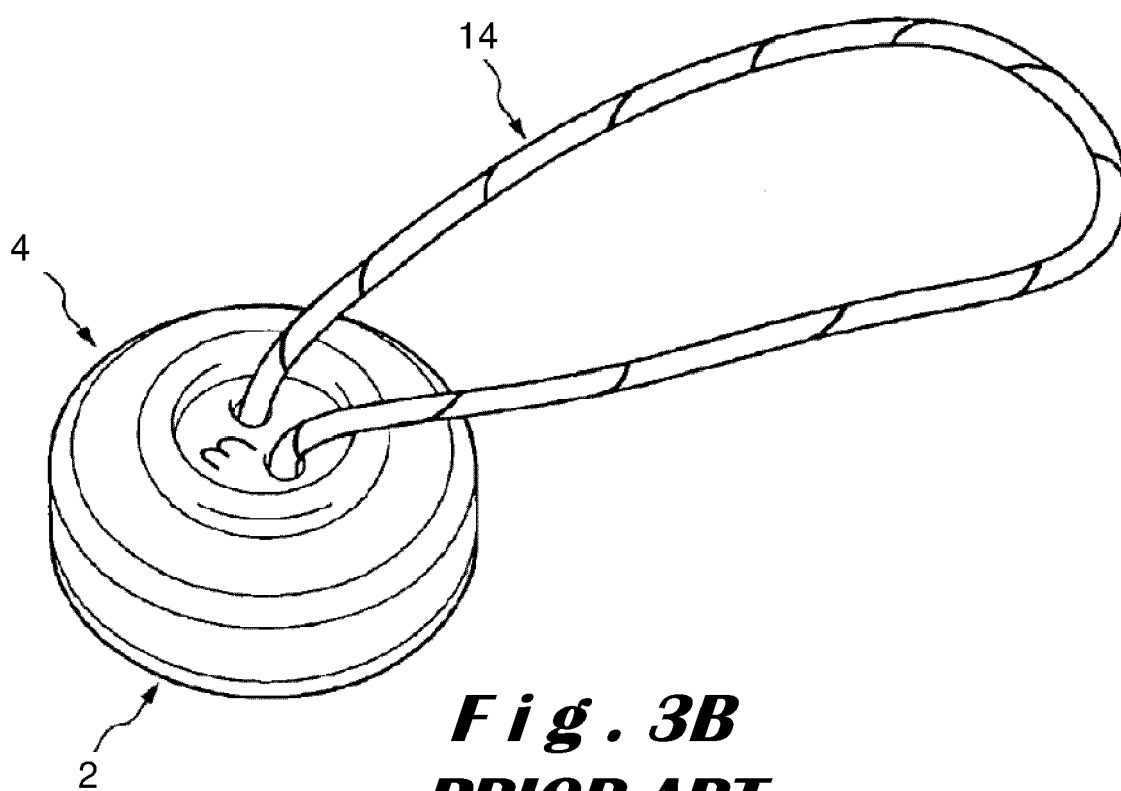
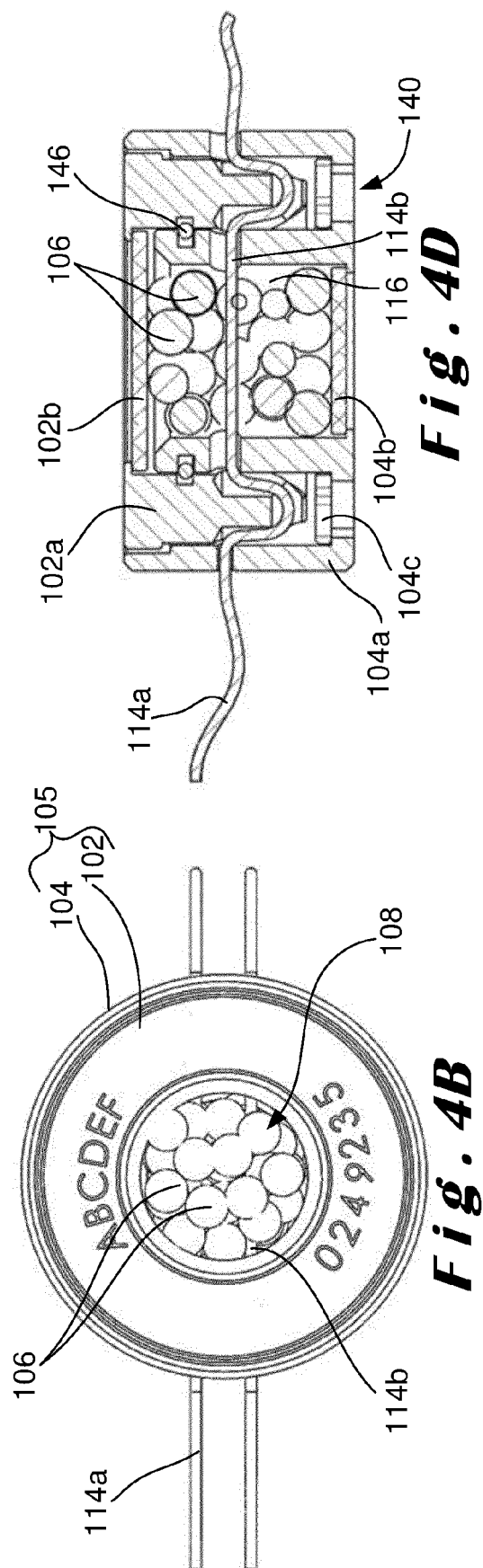
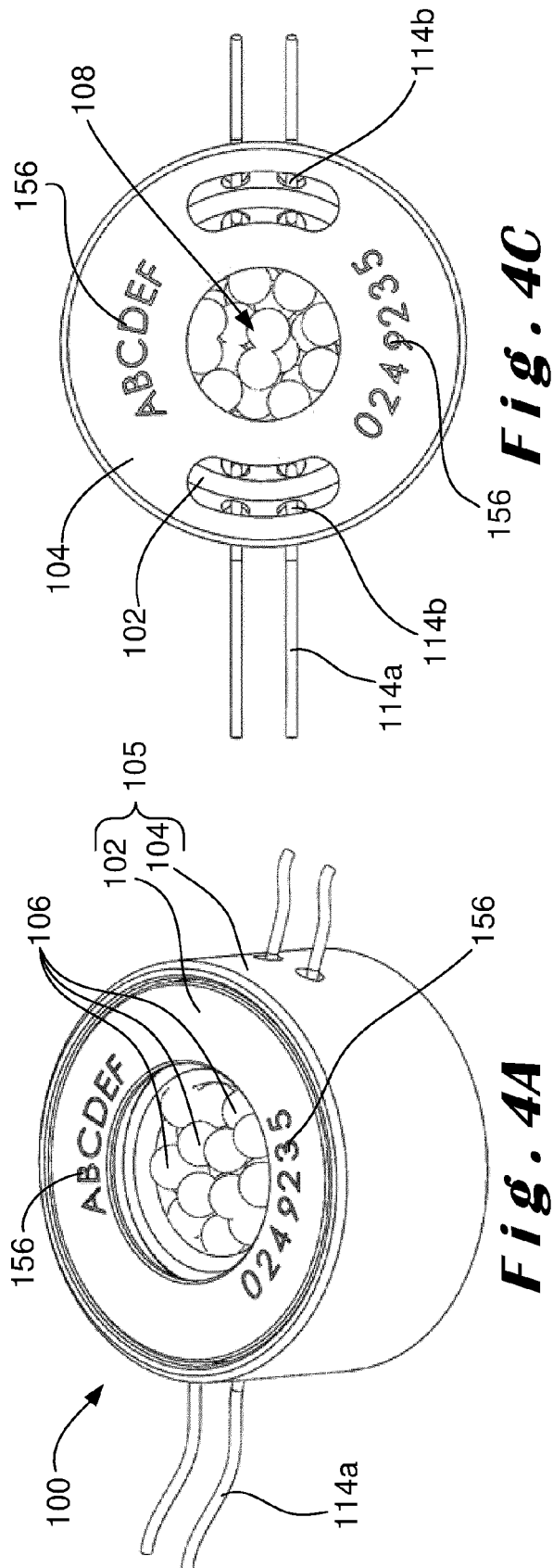


Fig. 3B
PRIOR ART



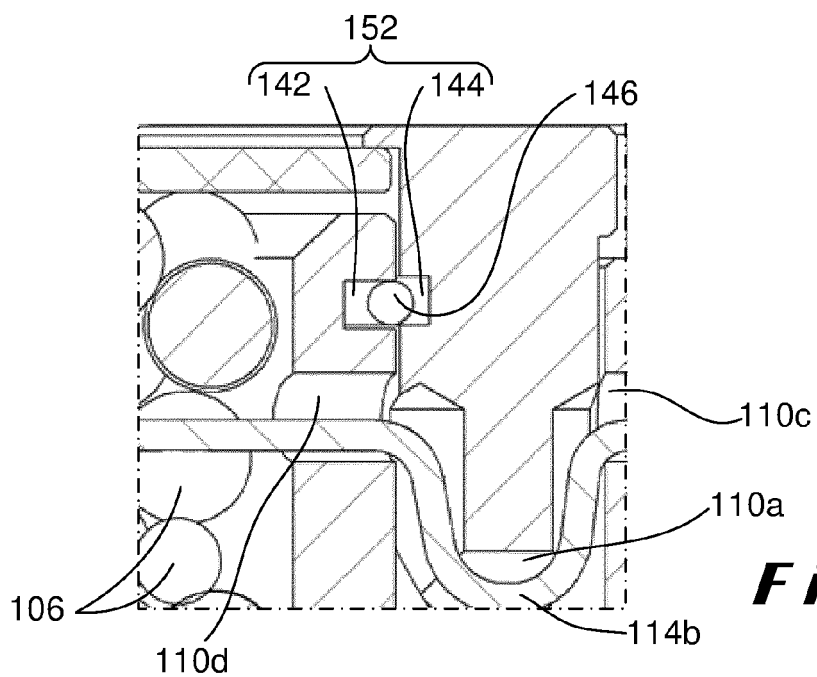


Fig. 5

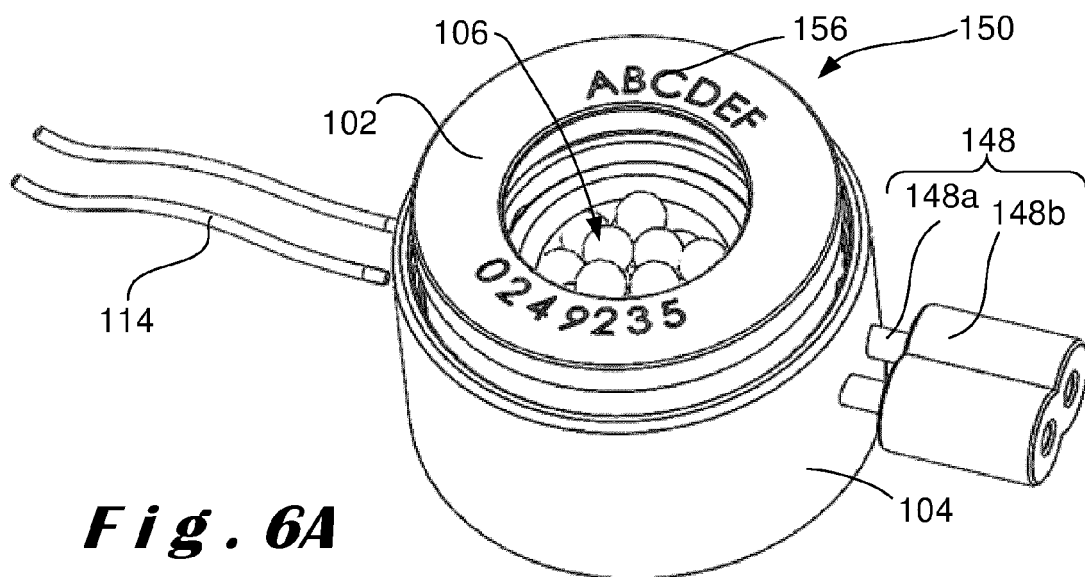


Fig. 6A

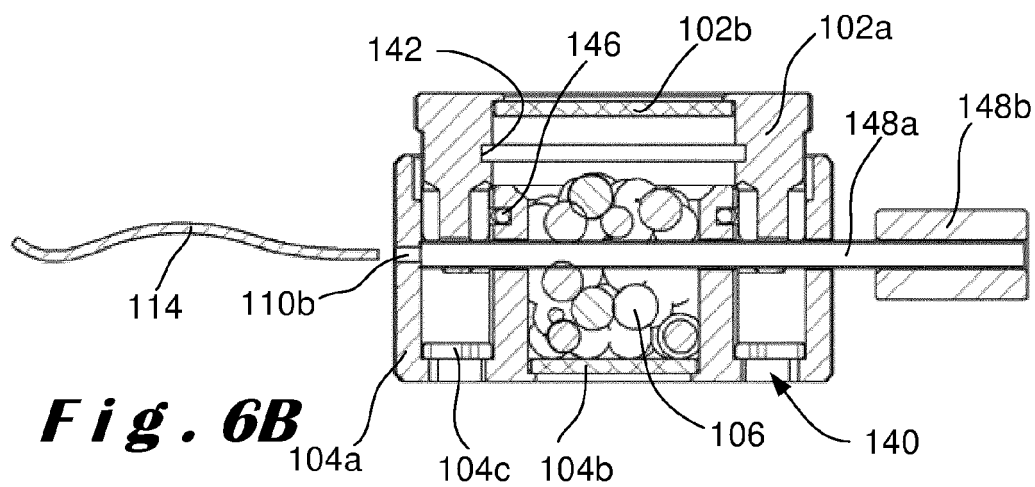
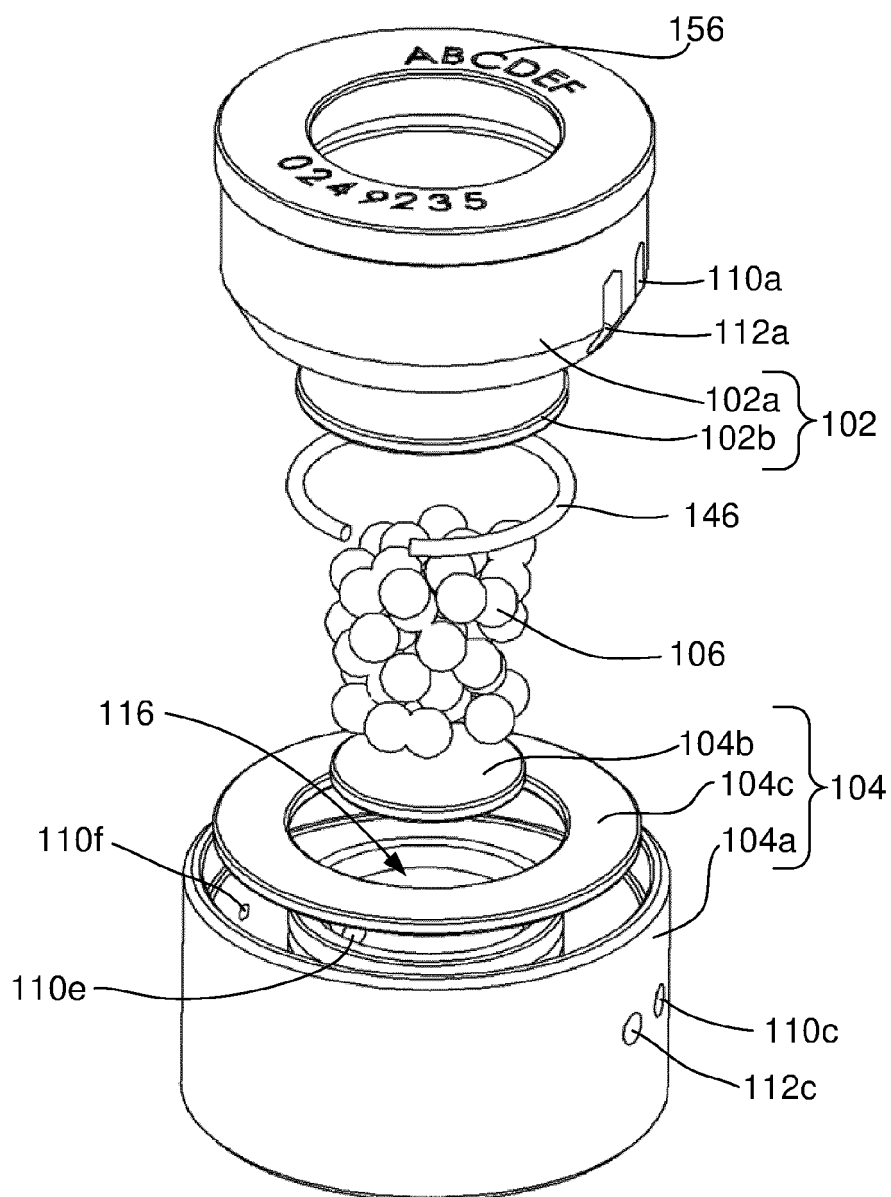
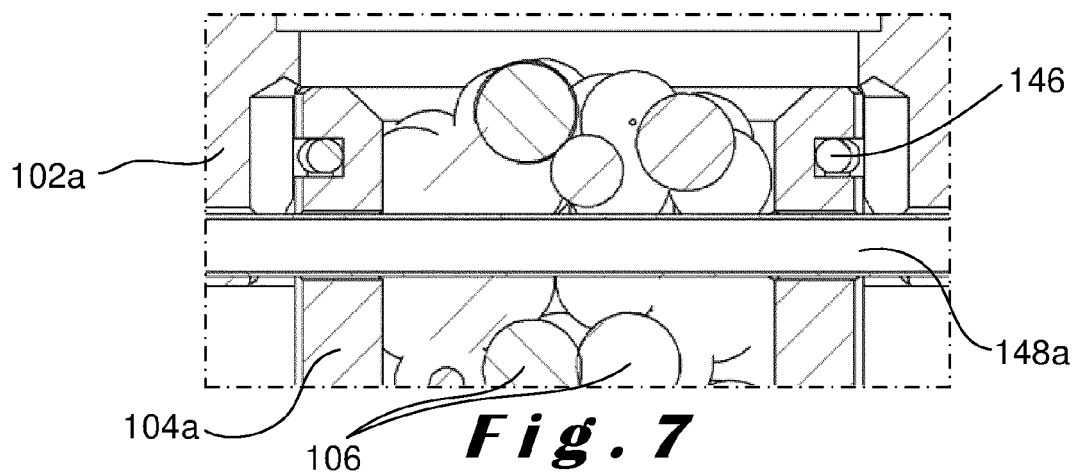


Fig. 6B



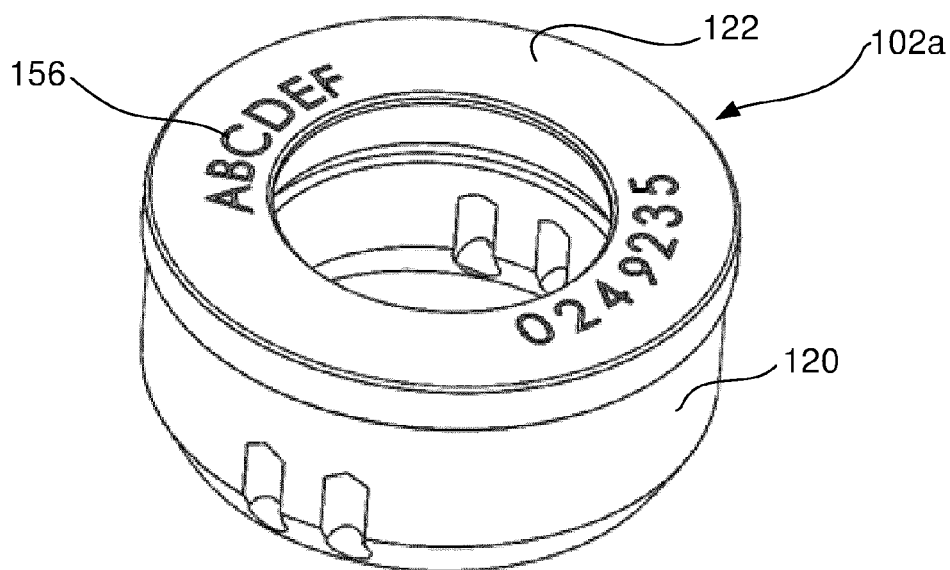


Fig. 9A

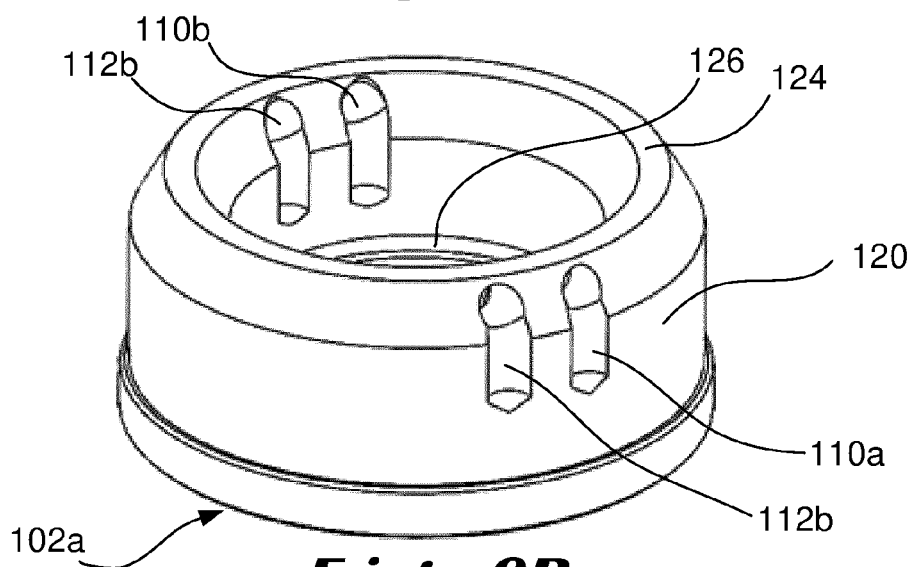


Fig. 9B

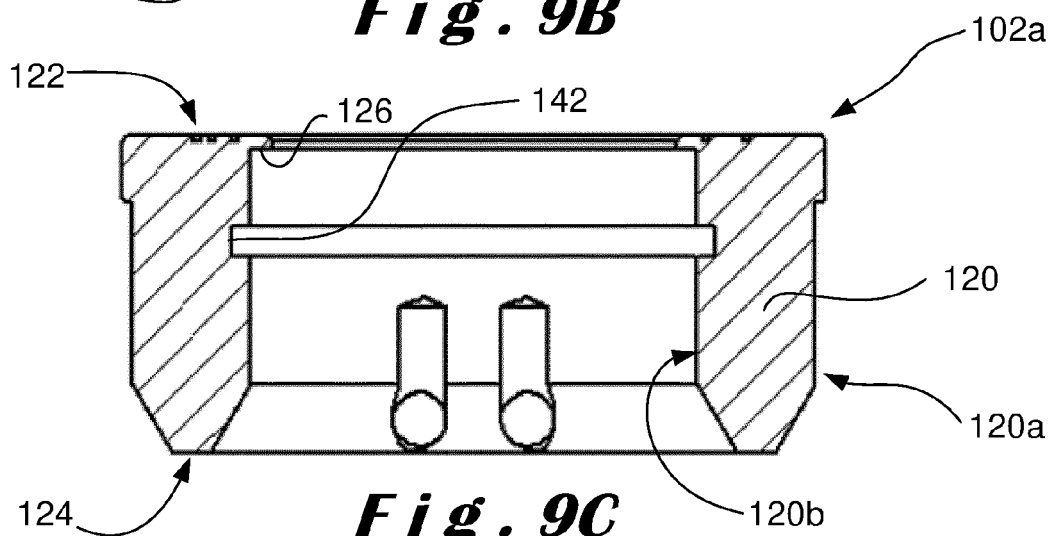


Fig. 9C

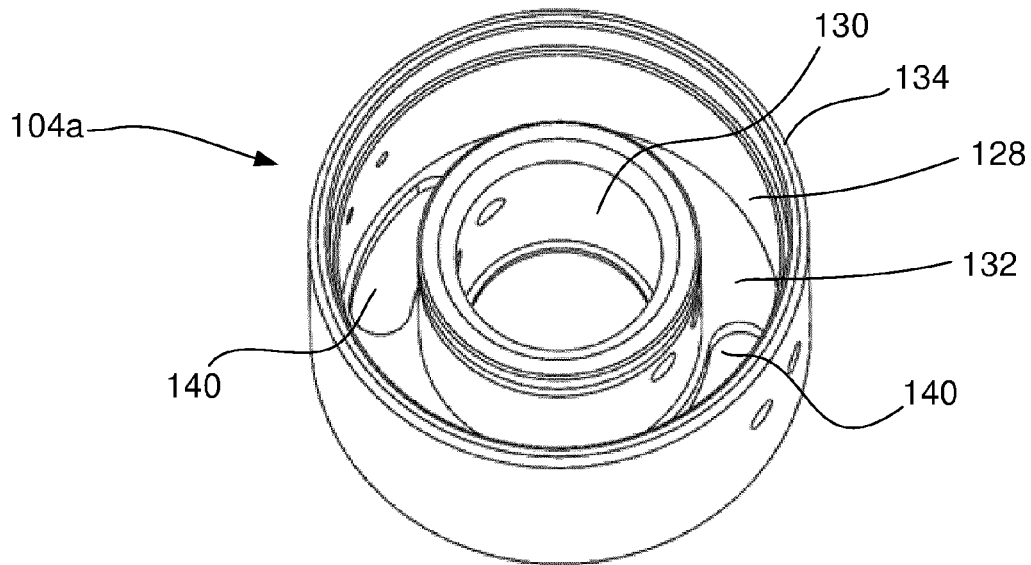


Fig. 10A

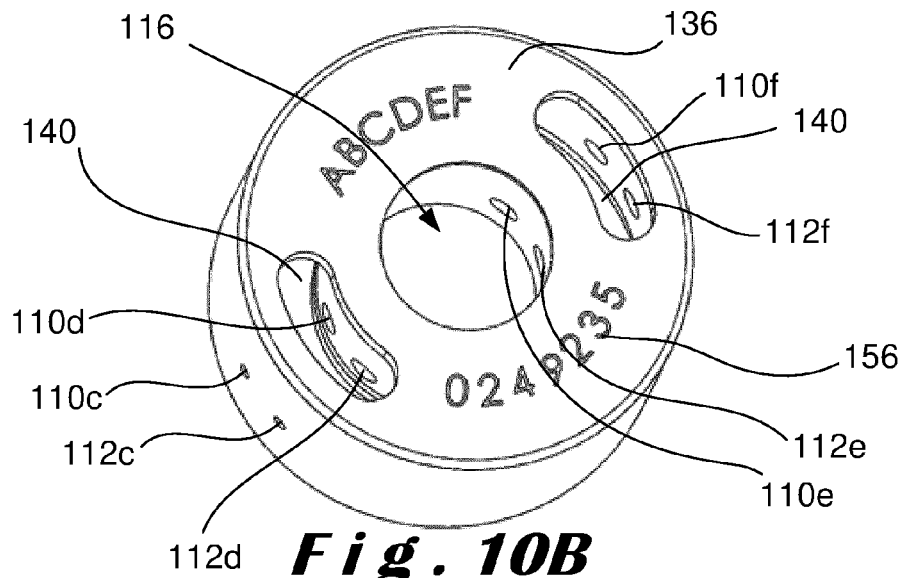


Fig. 10B

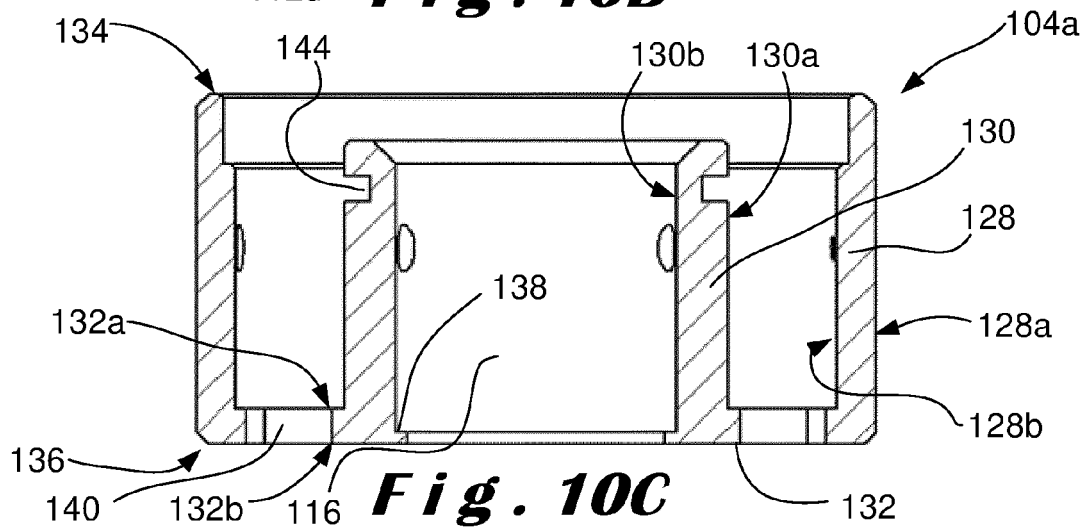


Fig. 10C



EUROPEAN SEARCH REPORT

Application Number

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2008/217931 A1 (BOURRIERES FRANCIS [FR] ET AL) 11 September 2008 (2008-09-11) * paragraphs [0028], [0029], [0032], [0033], [0039] - [0042] * * figures 1-3 *	1-12, 14-16	INV. G09F3/03
X	US 4 118 057 A (RYAN MICHAEL J) 3 October 1978 (1978-10-03) * column 2, line 4 - column 4, line 20 * * pages 1-7 *	1-12, 14-16	
A	US 4 389 063 A (RYAN MICHAEL J) 21 June 1983 (1983-06-21) * column 4, line 45 - column 5, line 13 * * figures 1-8 *	1-12, 14-16	
			TECHNICAL FIELDS SEARCHED (IPC)
			G09F
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 10 November 2021	Examiner Zanna, Argini
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	



Application Number

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-12, 14-16

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

**LACK OF UNITY OF INVENTION
SHEET B**

Application Number

EP 21 17 5778

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-12, 14-16**Sealing system for sealing an item and use thereof**

2. claims: 13, 17**Verification device for verifying a sealing system and use thereof**

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 21 17 5778

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

10-11-2021

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REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- **R.G. JOHNSTON ; J.S. WARNER.** Unconventional Security Devices. *Journal of Physical Security*, 2014, vol. 7 (3), 102-104 **[0010]**