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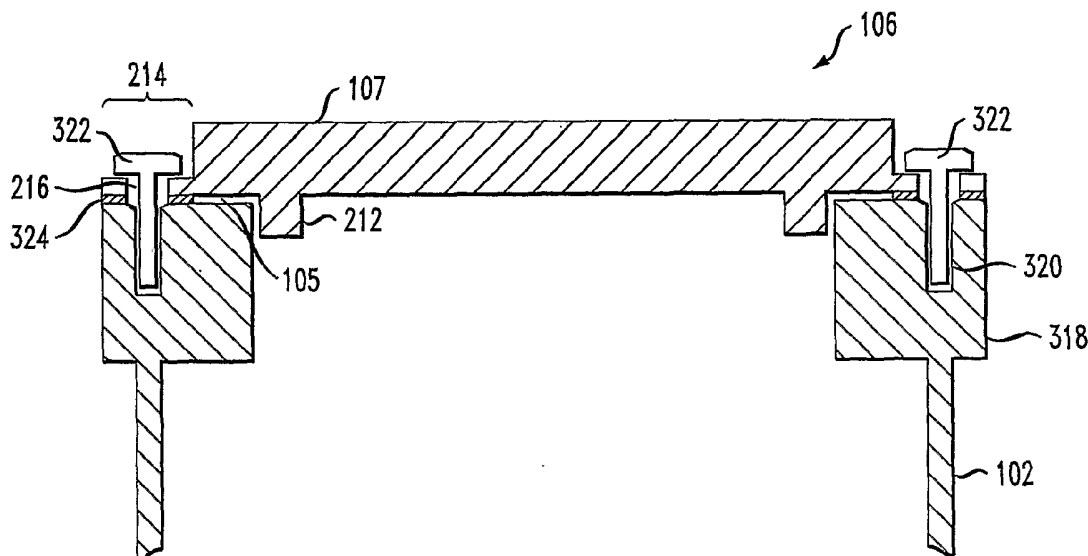
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(54) Title: ARTICLE COMPRISING A MISSILE CANISTER COVER



(57) Abstract: The illustrative embodiment of the present invention is a launch system that includes a missile canister cover (106) that, in use, is attached to a missile canister (102). The cover (106) is capable of being blown off of the canister (102) before there is any contact between the nose of the missile (108) and the cover (106) and is further capable of withstanding a higher ambient pressure than internal canister pressure. These capabilities are achieved based on an attention to material mechanics and the prevailing geometry of the system.

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ARTICLE COMPRISING A MISSILE CANISTER COVER

Statement Regarding Federally Sponsored Research or Development

[0001] The U.S. Government has a paid-up license in this invention and the right in limited circumstances to require the patent owner to license others on reasonable terms as provided for by the terms of Contract No. DAAH01-03-C-0035 awarded by the U.S. Government.

Field of the Invention

[0002] The present invention relates to canistered missile, and more particularly to covers for missile canisters.

Background of the Invention

[0003] It is well known in the art to launch a missile from a canister. The canisters are typically round or square tubes that contain a missile, missile-launch hardware such as rails and/or sabots, and electronics for initiating launch. In addition to functioning as a launch system, the canisters provide environmental protection for the missile, simplify missile-handling issues, and provide an efficient and long-term solution for missile storage.

[0004] In order to provide full environmental protection for the missile and other components within the canister, the canister must be sealed. This is typically done using a cap or cover. The cover is ideally able to protect or isolate the missile from a variety of environmental factors and must provide unimpeded passage of the missile upon launch.

[0005] A variety of canister covers are known. Some covers tear or shatter upon contact with the missile during launch. This is acceptable for some but not all types of missiles. In particular, some missiles (*e.g.*, LAM, PAM, *etc.*) include fragile mechanisms in the nose that could be damaged on impact with the cover. For these types of missiles, the canister cover must blow off *without* making contact with the missile.

[0006] Non-contact covers are typically more elaborate than tear-through designs since they must be actuated to release. This usually equates to increased weight, complexity, and expense.

Summary of the Invention

[0007] The present invention provides a cover for a missile canister that avoids some of the costs and disadvantages of the prior art.

[0008] The illustrative embodiment of the present invention is a launch system that includes a canister and a missile, in addition to the canister cover.

[0009] A canister cover in accordance with the present invention is capable of:

- Being blown off of the canister before there is any contact between the nose of the missile and the cover; and
- Withstanding a higher ambient pressure than internal canister pressure.

These capabilities are provided without any moving parts; rather, they are realized based on an attention to material mechanics and the prevailing geometry of the system.

[0010] More particularly, in accordance with the illustrative embodiment, the capabilities described above are obtained by:

- Segregating the canister into two regions —a main region and a marginal regional— that have different structural properties or characteristics, wherein the marginal region is disposed near the outer edge of the cover and the main region is disposed inward of the marginal regional.
- Attaching the marginal region to the wall of the missile canister.

[0011] In the illustrative embodiment, the structural characteristic that differs between the regions of the cover is the thickness of the region. In particular, the marginal region is thinner than the main region.

[0012] Since the marginal region is thinner than the main region, and by virtue of the way in which the cover is attached to the canister, the cover breaks directly over the canister wall when exposed to an elevated internal canister pressure. The break occurs in the marginal region, or at the interface between the marginal region and the main region. As a consequence, a single large piece representing the main region of the cover is blown off of the canister.

[0013] When the cover is exposed to an external pressure, there is a relatively limited build-up of stress/strain at the interface of the marginal region and the main region. This is because the marginal region is attached to and supported by the forward end of the missile canister. In fact, on exposure to external pressure, the cover might fail at the main region, which is unsupported by the canister,

before a failure occurs at the marginal region. On the other hand, to the extent that an *internal* pressure acts on the cover, high levels of stress/stain will build at the interface of the marginal region and the main region since this region of the cover is not supported against forces that are applied from the *inside* of the canister. As a consequence, the cover fractures at a relatively lower internal pressure than external pressure.

[0014] If an imperfection exists in the cover at some location along the marginal region, a gap or fracture might occur at that location when exposed to elevated internal pressure. Were that to occur, pressure would dissipate such that the cover would not blow off of the canister. To that end, the cover is physically adapted to equalize the response of the marginal region to internal pressure, regardless of location-to-location variations in the marginal region. In the illustrative embodiment, that adaptation is a ridge of material.

Brief Description of the Drawings

[0015] **Figure 1** depicts a missile launcher including a missile canister and a missile-canister cover in accordance with the illustrative embodiment of the present invention.

[0016] **Figure 2** depicts a bottom view of the missile-canister cover.

[0017] **Figure 3** depicts a side view of the missile-canister cover.

[0018] **Figure 4** depicts a cross-sectional view of an embodiment of the missile-canister cover in use, coupled to the missile canister.

[0019] **Figure 5** depicts a top view of a missile-canister cover in accordance with the illustrative embodiment of the present invention, wherein the cover is bolted to a missile canister.

[0020] **Figure 6** depicts a top view of the missile-canister cover of Figure 5 after it has ruptured due to exposure to an internal canister pressure that exceeds the pressure tolerance of the cover.

Detailed Description

[0021] Figure 1 depicts missile launcher **100** in accordance with the illustrative embodiment of the present invention. Launcher **100** includes missile canister **102**, canister cover **106**, and missile **108**. Canister cover **106** is coupled to forward end **104** of canister **102**. Typically, cover **106** is bolted to canister **102**. Missile **108** resides within canister **102**. Side **105** of cover **106**, which is

exposed to the interior of canister **102** when the cover is attached to the canister, is referred to herein as the "**inside surface**" of cover **106**. Side **107** of cover **106**, which is exposed to the ambient environment when the cover is attached to missile canister **102**, is referred to herein as the "**outside surface**" of cover **106**.

[0022] Canister **102** usually contains any one or more of a variety of internal elements or mechanisms, as is well known to those skilled in the art. Since these internals are not germane to an understanding of the present invention, they will not be described in this specification.

[0023] Figure 2 depicts further detail of the inside surface of canister cover **106**, in accordance with the illustrative embodiment of present invention. In the illustrative embodiment, canister cover **106** has a polygonal shape; in particular, cover **106** has a substantially square shape. A cover having this shape is typically used in conjunction with a canister that has a square cross section. In some other embodiments, canister cover **106** has a different polygonal shape. In some further embodiments, canister cover **106** has a circular shape, which would be used in conjunction with a canister having a circular cross section.

[0024] With continuing reference to Figure 2, canister cover **106** includes main region **210** and marginal regional **214**. Main region **210** includes all the area within dashed line **209** and marginal region **214** encompasses all portions of the cover outside of dashed line **209**. It is understood that line **209** is not a feature of canister cover **106**; it appears simply for pedagogical purposes. Marginal region **214** is distinguished from main region **210** by its tendency to break or fragment before main region **210**. As described in further detail later in this specification, this behavior is due to a physical/structural difference between main region **210** and marginal region **214**.

[0025] Marginal region **214** includes holes **216** for receiving a bolt, *etc.*, by which canister cover **106** is attached to canister **102**. Main region **210** includes a physical adaptation that enables cover **106** to resist pressure equally at all locations along the marginal region (when cover **106** is attached to canister **102**). In the illustrative embodiment depicted in Figure 2, the physical adaptation is ridge **212** that depends from the inside surface of cover **106**.

[0026] As depicted in Figure 2, ridge **212** forms a continuous ring within main region **212**. As shown in Figure 3, which is a cross-section through cover **106** at A-A in Figure 2, ridge **212** extends downward (into the interior of canister **102**

when the cover is coupled to canister **102**). In some embodiments, ridge **212** is formed of the same material as the rest of main region **210**. In some of those embodiments, main region **210** is monolithically formed; that is, ridge **212** is simply formed (*e.g.*, moulded, cut, *etc.*) from the piece of material that serves as main region **210**. In some other of those embodiments, ridge **212** is attached to the surface of main region **210**. In some further embodiments, ridge **212** is formed from a different material than the rest of main region **210** and is attached to its surface.

[0027] Figure 4 depicts further detail of missile launcher **100**. In Figure 4, missile cover **106** is coupled to missile canister **102**.

[0028] It was previously disclosed that marginal region **214** is distinguished from main region **210** by a tendency to break or fragment before main region **210**. In the embodiment that is depicted in Figure 4, this is due to the fact that marginal region **214** is thinner than main region **210**. In some other embodiments, this behavior results from materials selection, wherein a different material is selected for main region **210** than marginal region **214**. That is, the material selected for marginal region **214** has a tendency to break or fragment under pressure at a lower pressure than the material selected for main region **210**. In some additional embodiments, the interface between main region **210** and marginal region **214** is pre-stressed or pre-strained, with the result that the interface fractures before either main region **210** or marginal region **214**. The stress/strain can result from using dissimilar materials in the two regions, or due differences in crystal structure of the same material, as can develop due to processing conditions, *etc.*

[0029] Cover **106** is coupled to missile canister **102** via bolts **322**. In particular, bolt **322** extends through hole **216** in marginal region **214** and engages bolt-receiving hole **320** in forward portion **318** of canister **102**. Gasket **324** is disposed between the bottom surface of cover **106** at marginal region **214** and the upper surface of forward portion **318** of canister **102**. Gasket **324** provides a pressure-tight seal.

[0030] It accordance with the illustrative embodiment, cover **106** is released from canister **102** and blown away from canister **102** during launch but *before* the nose of missile **108** has a chance to contact the cover. The cover releases due to the pressure generated from exhaust gases on when the missile fires. The design of cover **106** is, therefore, a function of the internal pressure that is developed

when the missile ignites and materials composition of cover **106**. The internal pressure that develops depends on missile type and the dimensions of the canister. Those skilled in the art will be able to design and build cover **106**, after reading the present disclosure, as a function of desired materials of construction, missile type and canister dimensions. Suitable materials for cover **106** include for example, aluminum or glass-filled nylon. More generally suitable materials include any isotropic or quasi-isotropic material with predictable mechanical properties.

[0031] As previously described, marginal region **214** is less able to withstand pressure than main region **210**. As a consequence, cover **106** fractures at marginal region **214** due to launch pressure.

[0032] Launch system **100** must be able to withstand elevated external pressure. In particular, it is important that when cover **106** is exposed to such elevated external pressures, it does not fracture. In fact, it is possible that cover **106** will be exposed to external pressures that are as high as the internal pressure that is developed by the missile plume (which causes cover **106** to blow off of canister **102**). As a consequence, cover **106** must be able to withstand a higher level of external pressure (*i.e.*, pressure against its outside surface **107**) than internal pressure (*i.e.*, pressure against its inside surface **105**). In other words, assume that cover **106** fractures when the internal canister pressure reaches magnitude **P1**, wherein the elevated pressure results from the release into canister **102**, on ignition, of missile exhaust gases. Cover **106** will not fracture, however, when exposed to an external pressure of the same magnitude, **P1**.

[0033] In accordance with the illustrative embodiment, this differential response to pressure is achieved by the way cover **106** is supported. In particular, in the illustrative embodiment, inside surface **105** of cover **106** is supported at marginal region **214**, but outside surface **107** is not supported.

[0034] Specifically, to the extent an *external* pressure is applied, marginal region **214**, the interface of the marginal region and the main region, and the peripheral portion of main region **210** deflect only a minimal distance (*i.e.*, the thickness of gasket **324**) until they abut the upper surface of forward end **318** of canister **102**. They are, therefore, prevented from deflecting to any substantial degree. As a consequence, there is a relatively limited build-up of stress/strain in the interface of main region **210** and marginal region **214**. As a result, a break does not occur. To the extent that an *internal* pressure acts on cover **106**, high levels

of stress/stain will build at the interface of marginal region **214** and main region **210**. This occurs since cover **106** is not supported against forces that are applied against it from the *inside* of the canister. As a consequence, cover **106** has a diminished ability to resist internal pressure as compared to its ability to resist external pressure.

[0035] As previously described, ridge **212** equalizes the response of marginal region **214** to internal canister pressure. In particular, ridge **212** prevents cover **106** from fracturing at a single location along marginal region **214**, as might otherwise occur if marginal region **214**, at that location, were structurally compromised relative to other locations along the marginal region. If marginal region **214** were to fracture at a single location, then pressure would rapidly dissipate at that fracture and cover **106** would not blow off, as desired.

[0036] Figures 5 and 6 depict a top view of launch system **100** before and during launch.

[0037] Figure 5 depicts launch system **100** in a pre-launch state. Cover **106** is bolted to canister **102** (not depicted in Figure 5) via bolts **322** in marginal region **214**. Figure 6 depicts launch system **100** after cover **106** has blown off canister **102**. As depicted in Figure 6, cover **106** fractures at **626** near interface of marginal region **214** and main region **210**. The main region flies off of canister **102** in a substantially single piece, while marginal region **214** remains attached to upper surface of forward region **318** of canister **102**. Missile **108** is visible within canister **102**. Egress is now unimpeded such that there will be no contact between the nose of missile **108** and missile cover **106**.

[0038] It is to be understood that the above-described embodiments are merely illustrative of the present invention and that many variations of the above-described embodiments can be devised by those skilled in the art without departing from the scope of the invention. It is therefore intended that such variations, and others that will occur to those skilled in the art in view of the present disclosure, be included within the scope of the following claims and their equivalents.

We claim:

- 1.** An article comprising a cover for a canister, wherein said cover comprises:
a main region; and
a marginal region, wherein:
 - (i) said cover couples to said canister at said marginal region;
 - (ii) said marginal region completely surrounds said main region;and
 - (iii) said cover has a physical adaptation that causes it fragment in said marginal region or at an interface of said main region and said marginal region, but not in said main region, when exposed to a first pressure.
- 2.** The article of claim 1 wherein said physical adaptation is that said marginal region is thinner than said main region.
- 3.** The article of claim 1 wherein said physical adaptation is that said marginal region comprises a first material and said main region comprises a second material, wherein said first material fractures under exposure to pressure before said second material.
- 4.** The article of claim 1 wherein said physical adaptation is a pre-stressed interface between said marginal region and said main region.
- 5.** The article of claim 1 wherein said cover comprises a single layer of a homogenous material.
- 6.** The article of claim 1 wherein said cover comprises a single layer of a composite material.
- 7.** The article of claim 1 further comprising a physical adaptation that enables said cover to resist pressure equally at all locations along said marginal region.
- 8.** The article of claim 7 wherein said physical adaptation comprises a ridge, wherein said ridge is disposed on an inside surface of said cover.

9. The article of claim 8 wherein said ridge is disposed in said main region, and further wherein said marginal region and said ridge are concentric.

10. The article of claim 8 wherein said ridge is disposed in said main region within 2 inches of a wall of said canister.

11. The article of claim 7 wherein said main region comprises a first material, and further wherein said ridge comprises said first material.

12. The article of claim 1 wherein said marginal region completely overlies a wall of said canister.

13. The article of claim 1 further comprising said canister.

14. The article of claim 13 further comprising a missile, wherein said missile is disposed within said canister.

15. An article comprising a cover for a canister, wherein said cover comprises:

a main region, wherein said main region comprises a single layer of a first material, and further wherein said main region has a first thickness;

a marginal region, wherein said marginal region depends from, and surrounds, said main region, and wherein said cover is coupled to said canister at said marginal region, and wherein said marginal region comprises said single layer of said first material, and further wherein said marginal region has second thickness; and wherein:

said second thickness is thinner than said first thickness; and

said marginal region is supported from below by a wall of said canister.

16. The article of claim 15 wherein a ring-shaped portion of said main region depends from an inside surface of said cover.

17. An article comprising a cover for a canister, wherein said cover comprises a unitary layer of material and a first physical adaptation that causes said cover to fracture into:

- (i) a relatively larger first piece that does not remain coupled to said canister;
- and (ii) a relatively smaller, ring-shaped, second piece that remains coupled to said canister,

wherein said cover fractures on exposure to a first pressure, but only when said first pressure is an internal canister pressure, not an external pressure.

18. The article of claim 17 wherein said physical adaptation is that said cover comprises a main region and a marginal region, and wherein said marginal region encircles said main region, and wherein said marginal region is thinner than said main region, and further wherein said marginal region overlies a wall of said canister.

19. The article of claim 18 wherein said cover comprises a second physical adaptation, wherein said second physical adaptation enables said cover to resist pressure equally at all locations along said marginal region.

20. The article of claim 17 further comprising said canister.

What is claimed is:

1. An article comprising a cover for a canister, wherein said cover comprises:
 - a main region; and
 - a marginal region, wherein:
 - (i) said cover couples to said canister at said marginal region;
 - (ii) said marginal region completely surrounds said main region;
 - (iii) said marginal region completely overlies a surface that limits deflection of said marginal region in a canister-inward direction;
 - (iv) a portion of said main region that is proximal to said marginal region overlies said surface, thereby limiting deflection of said portion of said main region in said canister-inward direction; and
 - (v) said main region and said marginal region differ from one another as to a structural property or characteristic.
2. The article of claim 1 wherein the differing structural property or characteristic is a respective thickness of said main region and said marginal region, said marginal region being thinner than said main region.
3. The article of claim 1 wherein the differing structural property or characteristic is a respective material composition of said main region and said marginal region, said marginal region comprising a first material and said main region comprising a second material, wherein said first material fractures under exposure to pressure before said second material.
4. The article of claim 1 further comprising a pre-stressed interface between said marginal region and said main region.
5. The article of claim 1 wherein said cover comprises a single layer of a homogenous material.
6. The article of claim 1 wherein said cover comprises a single layer of a composite material.

7. The article of claim 1 further comprising a physical adaptation that enables said cover to resist pressure equally at all locations along said marginal region.

8. The article of claim 7 wherein said physical adaptation comprises a ridge, wherein said ridge is disposed on an inside surface of said cover.

9. The article of claim 8 wherein said ridge is disposed in said main region, and further wherein said marginal region and said ridge are concentric.

10. The article of claim 8 wherein said ridge is disposed in said main region and radially inward of said surface that underlies said marginal region and said portion of said main region, and further wherein said ridge is radially inward of said surface by no more than about 2 inches.

11. The article of claim 7 wherein said main region and said ridge comprise the same material.

12. The article of claim 1 further comprising said canister.

13. The article of claim 12 further comprising a missile, wherein said missile is disposed within said canister.

14. An article comprising a cover for a canister, wherein said cover comprises:

- a centrally-disposed main region;
- a peripherally-disposed marginal region;
- a first physical adaptation that causes said cover to fracture in said marginal region or at an interface between said main region and said marginal region when said cover is exposed to an internal canister pressure having a first magnitude; and
- a second physical adaptation that prevents said fracture from occurring when said cover is exposed to an external pressure having said first magnitude.

15. The article of claim 14 further comprising a third physical adaptation that enables said cover to resist pressure equally at all locations along said marginal region.

16. The article of claim 14 wherein said first physical adaptation comprises a difference in a structural property or characteristic between said marginal region and said main region.

17. The article of claim 14 wherein said first physical adaptation comprises a pre-stressed interface between said marginal region and said main region.

18. The article of claim 14 wherein said second physical adaptation comprises a surface that underlies said marginal region and a portion of said main region of said cover, wherein said surface limits deflection of said marginal region and said portion of said main region in a canister-inward direction.

19. The article of claim 15 wherein said third physical adaptation comprises a ridge that depends from an inside surface of said main region of said cover, wherein said ridge is disposed proximal to said marginal region.

20. The article of claim 14 further comprising said canister.

$1/3$

FIG. 1

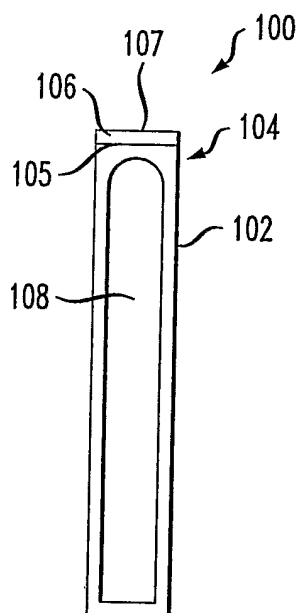


FIG. 2

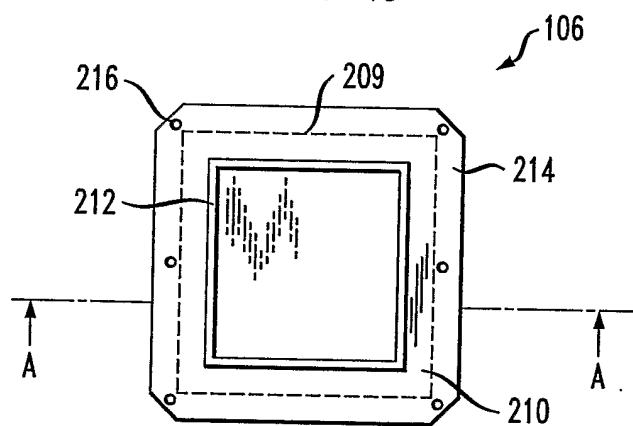


FIG. 3

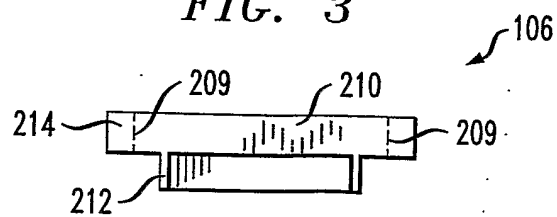


FIG. 4

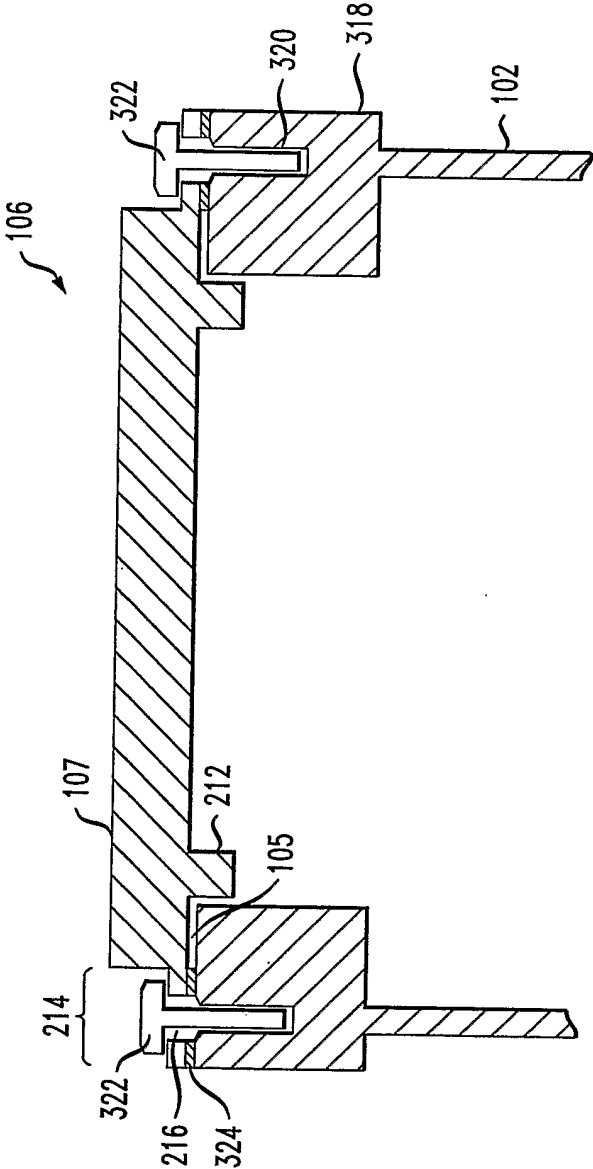


FIG. 6

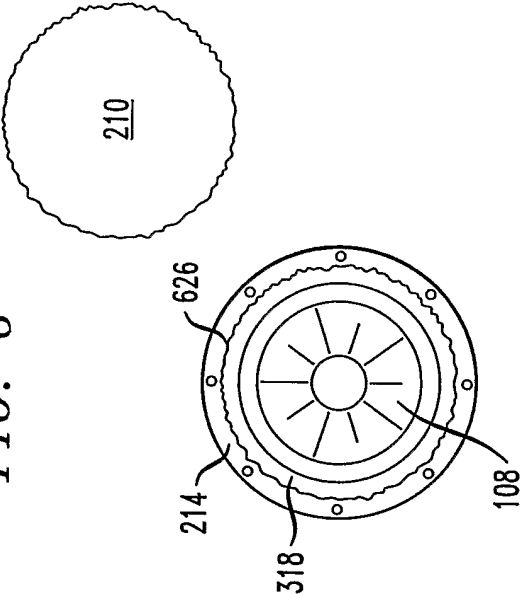
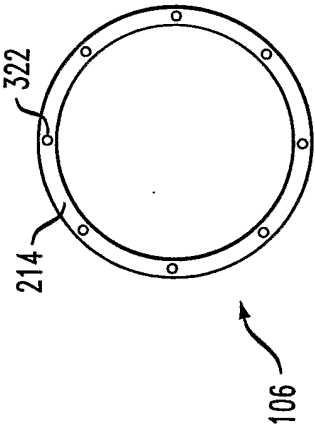


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. F41F3/077

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)
F41F F42B

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 389 938 A (SIGRIST ET AL) 28 June 1983 (1983-06-28)	1-7, 12-18,20
Y	abstract column 2, line 6 - column 4, line 23 figures 1,2	8-11,19
Y	----- US 6 363 855 B1 (STEVEN ET AL) 2 April 2002 (2002-04-02) column 3, lines 52,53 figure 1	8-11,19
X	----- US 6 123 005 A (KUCHTA ET AL) 26 September 2000 (2000-09-26) abstract column 2, lines 21-53 column 5, lines 41-51 figures 4,5	1,3,7, 12-14
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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