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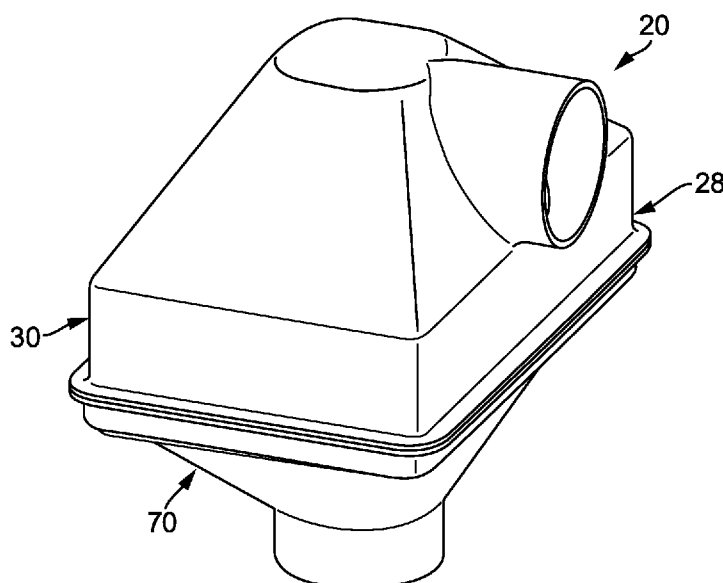


FIG. 1A

(57) Abstract: A filter assembly that comprises a housing assembly and a sealing element. The housing assembly comprises a housing portion and a lid and contains at least a portion of a filter element. The housing portion comprises a channel formed in an upper surface thereof. The sealing element comprises a top surface, a bottom surface, and a protrusion extending away from the bottom surface thereof. The protrusion fits within and forms a first seal with the channel, thereby aligning the housing portion with the sealing element and sealing the sealing element and the housing portion. The lid forms a second seal with the top surface of the sealing element and encloses at least one side of the housing portion such that the lid and the housing portion contain at least the portion of the filter element.

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SELF-ALIGNING FILTER ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present invention claims the benefit of priority to Indian Patent Application No. 201641036102, filed October 21, 2016, and the contents of which are incorporated herein by reference in its entirety

FIELD

[0002] The present invention relates generally to filter assemblies.

BACKGROUND

[0003] Filter assemblies may include a filter housing portion and a diaphragm that should be sealed together. However, often the diaphragm is not completely aligned with the housing portion during installation or assembly, which prevents the diaphragm and the housing portion from completely sealing with each other. The misalignment causes the diaphragm to be incorrectly set on the housing portion such that the diaphragm and the housing portion improperly and incompletely seal with each other, which causes subsequent leakage at the customer end.

[0004] As shown in FIGS. 13 and 14, the filter assembly 120 comprises a lid 130, a diaphragm 150 with a projection 152, and a housing portion 170 with a channel 172. The channel 172 of the housing portion 170 and the projection 152 of the diaphragm 150 may each have a rectangular cross-sectional shape. As shown in FIG. 14, this rectangular shape prevents the housing portion 170 and the diaphragm 150 from fully and effectively sealing with each other.

[0005] In attempt to obtain a proper seal between the diaphragm 150 and the housing portion 170, a roller process, which is an additional process during production, may be used. In order to ensure a proper seal between the diaphragm 150 and the housing portion 170, the roller process is used at every assembly plant where the filter assembly is manufactured in order to avoid misalignment between the diaphragm 150 and the housing portion 170. During the roller process, the diaphragm 150 is pressed into place within the channel 172 of

the housing portion 170 before pushing the lid 130 onto the diaphragm 150. However, this process requires an extra step during production, which also increases the cost of the filter assembly 120.

SUMMARY

[0006] Various embodiments provide for a filter assembly that comprises a housing assembly and a sealing element. The housing assembly comprises a housing portion and a lid and contains at least a portion of a filter element. The housing portion comprises a channel formed in an upper surface thereof. The sealing element comprises a top surface, a bottom surface, and a protrusion extending away from the bottom surface thereof. The protrusion fits within and forms a first seal with the channel, thereby aligning the housing portion with the sealing element and sealing the sealing element and the housing portion. The lid forms a second seal with the top surface of the sealing element and encloses at least one side of the housing portion such that the lid and the housing portion contain at least the portion of the filter element when installed.

[0007] Various other embodiments provide for a filter assembly that comprises a filter element, a housing element, and a sealing element. The filter element comprises a filter media for filtering a fluid. The housing assembly comprises a housing portion and a lid and contains at least a portion of the filter element. The housing portion comprises a channel formed in an upper surface thereof. The sealing element comprises a top surface, a bottom surface, and a protrusion extending away from the bottom surface. The protrusion fits within and forms a first seal with the channel, thereby aligning the housing portion with the sealing element and sealing the sealing element and the housing portion. The lid forms a second seal with the top surface of the sealing element and encloses at least one side of the housing portion such that the lid and the housing portion contain at least the portion of the filter element.

[0008] These and other features (including, but not limited to, retaining features and/or viewing features), together with the organization and manner of operation thereof, will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, wherein like elements have like numerals throughout the several drawings described below.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0009] FIG. 1A is a perspective view of a filter assembly according to one embodiment.
- [0010] FIG. 1B is a cross-sectional view of the filter assembly of FIG. 1A.
- [0011] FIG. 2A is a perspective view of a filter element according to one embodiment.
- [0012] FIG. 2B is an enlarged view of a portion of FIG. 2A.
- [0013] FIG. 3A is a perspective view of an embodiment of a filter element.
- [0014] FIG. 3B is a perspective view of another embodiment of a filter element.
- [0015] FIG. 3C is a perspective view of yet another embodiment of a filter element.
- [0016] FIG. 4 is a cross-sectional view of a filter assembly according to another embodiment.
- [0017] FIG. 5A is a front view of a diaphragm according to one embodiment.
- [0018] FIG. 5B are perspective views of various embodiments of diaphragms.
- [0019] FIG. 5C are perspective views of other various embodiments of diaphragms.
- [0020] FIG. 6 is a cross-sectional, schematic view of a portion of a filter assembly according to one embodiment.
- [0021] FIG. 7A are perspective views of a sealing element and a housing portion according to one embodiment.
- [0022] FIG. 7B is a cross-sectional view of the sealing element and the housing portion of FIG. 7A.
- [0023] FIG. 8A are perspective views of a sealing element and a housing portion according to another embodiment.
- [0024] FIG. 8B is a cross-sectional view of the sealing element and the housing portion of FIG. 8A.

[0025] FIG. 9A are perspective views of a sealing element and a housing portion according to yet another embodiment.

[0026] FIG. 9B is a cross-sectional view of the sealing element and the housing portion of FIG. 9A.

[0027] FIG. 10A is a cross-sectional view of a sealing element and a housing portion another to still another embodiment.

[0028] FIG. 10B is a schematic view of approximate dimensions and angles of the sealing element and the housing portion of FIG. 10A.

[0029] FIG. 11A is a cross-sectional view of a sealing element and a housing portion another to another embodiment.

[0030] FIG. 11B is a schematic view of approximate dimensions and angles of the sealing element and the housing portion of FIG. 11A.

[0031] FIG. 12A is a cross-sectional view of a sealing element and a housing portion another to yet another embodiment.

[0032] FIG. 12B is a schematic view of approximate dimensions and angles of the sealing element and the housing portion of FIG. 12A.

[0033] FIG. 13 is a cross-sectional view of a conventional filter assembly.

[0034] FIG. 14 is a cross-sectional view of a portion of a conventional filter assembly.

DETAILED DESCRIPTION

[0035] The filter assembly 20 may be used within a variety of air filtration applications and systems. The filter assembly 20 may be, for example, an air filter assembly. Alternatively or additionally, the filter assembly 20 may be a part of a crankcase depression regulator (CDR) and/or a crankcase ventilation (CV) system.

[0036] As described further herein and shown in FIGS. 1B and 4, the filter assembly 20 comprises a sealing element 50 and a housing assembly 28 that comprises a housing portion

70 and a lid 30. The filter assembly 20 may also include other components, such as a filter element 22 that comprises a filter media 24.

[0037] As described further herein, the sealing element 50 comprises a protrusion 52 and the housing portion 70 comprises a channel 72, each of which includes geometry that is complementary to each other. The interface between the sealing element 50 and the housing portion 70 (i.e., the interface between the protrusion 52 of the sealing element 50 and the channel 72 of the housing portion 70) allows the sealing element 50 and the housing portion 70 to be properly and completely sealed to each other, even if the sealing element 50 and the housing portion 70 are misaligned relative to each other during assembly (which includes, for example, installation and sealing).

[0038] More specifically, due to the relative shapes and geometry of the protrusion 52 and the channel 72, the protrusion 52 and the channel 72 fix any relative misalignment between the sealing element 50 and the housing portion 70 by automatically realigning the sealing element 50 and the housing portion 70 as the protrusion 52 is inserted into the channel 72, thereby allowing the sealing element 50 and the housing portion 70 to have a complete sealing interface with each other. This automatic realignment allows a complete and proper seal to be created between the sealing element 50 and the housing portion 70, even if the sealing element 50 and the housing portion 70 are originally misaligned with each other to a large extent during assembly.

[0039] The complete seal is made without the use of an extra roller process during production in the assembly plant. Accordingly, the sealing element 50 and the housing portion 70 are sealed together in a cost-effective manner. Furthermore, since the protrusion 52 and the channel 72 are completely sealed with each other (and thus the sealing element 50 and the housing portion 70 are completely sealed with each other), leakage between the sealing element 50 and the housing portion 70 is significantly inhibited or prevented. Furthermore, the overall amount of scrap or scrap rate is minimized.

[0040] The Filter Housing

[0041] As shown in FIGS. 1A-1B and 4, the filter housing assembly 28 is configured to house or contain at least a portion of the sealing element 50. As shown in FIG. 1B, the housing assembly 28 may also house or contain at least a portion of the filter element 22.

The sealing element 50 and, optionally, the filter element 22, may fit within, be positioned within, mounted to, and aligned with the housing assembly 28.

[0042] The housing assembly 28 may include a housing portion 70 and a lid 30. The housing portion 70 may be an upper housing element or a lower housing element. The lid 30 can be the other of the upper housing element and the lower housing element and is configured to attach to the housing portion 70. Although the lid 30 is referred to as a “lid,” it is understood that the lid 30 can also be a housing portion of the housing assembly 28 (instead of a “lid”), as shown in FIG. 1B. The sealing element 50 and the filter element 22 can be positioned within the housing portion 70 and/or the lid 30. At least a portion of the sealing element 50 is positioned between the housing portion 70 and the lid 30 such that the housing portion 70 and the lid 30 are attached to each other and sealed together.

[0043] The housing assembly 28 (including the housing portion 70 and the lid 30) may have a variety of different cross-sectional shapes including, but not limited to rectangular (as shown in FIGS. 1A-1B) or circular (as shown in FIGS. 7A-9B). (It is understood, however, that the housing portion 70 shown in FIGS. 7A-9B may only be a portion of the housing portion 70 and that the housing portion 70 may include, for example, a lower compartment.) The shape of the housing portion 70 and the lid 30 may match each other such that the housing portion and the lid 30 can attach and seal with each other through the sealing element 50.

[0044] The housing portion 70 has an upper surface that faces toward the sealing element 50 (and the lid 30) when the filter assembly 20 is assembled.

[0045] The housing portion 70 is configured to seal with the sealing element 50 and the lid 30 is configured to press the sealing element 50 into or toward the housing portion 70. Accordingly, as shown in FIG. 6, the housing portion 70 includes a recess, groove, or channel 72 that is configured to directly abut and seal with the protrusion 52 of the sealing element 50, as described further herein. The channel 72 is formed in an upper surface of the housing portion 70 such that the channel 72 extends in an axial direction into the housing portion 70 (away from the sealing element 50 when the filter assembly 20 is assembled), where the axial direction may refer to the direction of fluid flow through the filter media 24.

Accordingly, the protrusion 52 of the sealing element 50 can extend into the channel 72 when the housing portion 70 and the sealing element 50 are assembled or attached together.

[0046] The Sealing Element

[0047] The gasket, sealing surface, projection, extension, or sealing element 50 provides a seal between the lid 30 and the housing portion 70 (as shown in FIGS. 1B and 4). The perimeter of the sealing element 50 approximately matches or corresponds (in size and shape) to the perimeter of the housing portion 70 (specifically the channel 72 of the housing portion 70) such that the sealing element 50 can align with and form a complete seal with the housing portion 70. For example, the sealing element 50 may have a rectangular shape to match the rectangular shape of the housing portion 70 (as shown in FIGS. 1A-2B). Alternatively, the sealing element 50 may have a circular shape to match the circular shape of the housing portion (as shown in FIGS. 7A-9B).

[0048] The sealing element 50 may be a variety of different components within the filter assembly 20 that are configured to seal with the housing portion 70. According to one embodiment, the filter assembly 20 comprises a sealing ring or rim that includes the sealing element 50 and extends around a perimeter of the housing portion 70 with an opening that extends through the center of the rim to allow fluid to flow through the middle of the sealing element 50. For example, as shown in FIGS. 1B and 2A-2B, the filter element 22 comprises the sealing element 50 such that the sealing element 50 is a part of the filter element 22, such as a portion of the rim or frame of the filter element 22 (where the rim or frame (that includes the sealing element 50) is attached to the filter media 24 of the filter element 22). Accordingly, the sealing element 50 may provide support to the rest of the filter element 22 and attach and seal the rest of the filter element 22 to the housing portion 70. Various examples and designs of filter elements 22 that may include the sealing element 50 are shown in FIGS. 3A-3C. It is understood that the rim may not be circular and may have a variety of different shapes, including, but not limited to, rectangular, oval or “racetrack” shapes.

[0049] According to another embodiment as shown in FIG. 4, the sealing element 50 extends around the perimeter of the housing portion 70 and does not include an opening in the center that extends through the sealing element 50 to prevent fluid from flowing through

the middle of the sealing element 50. Accordingly, fluid cannot flow through the sealing element 50 and the sealing element 50 divides the filter assembly 20 into two different portions or sections.

[0050] The area of the sealing element 50 approximately matches the cross-sectional area of the housing portion 70. Additionally, the sealing element 50 may be relatively thin and approximately flat (although it is understood that the sealing element 50 may include certain portions that protrude in either direction, as shown in FIGS. 5A-5C). For example, the sealing element 50 may be substantially round and therefore may have a substantially disc shape. According to one embodiment, the filter assembly 20 may comprise a diaphragm 26 that includes the sealing element 50. Various examples and designs of diaphragms 26 that may include the sealing element 50 are shown in FIGS. 5A-5C.

[0051] The sealing element 50 includes an upper or top surface that faces away from the housing portion 70 (and toward the lid 30) and a lower or bottom surface that faces toward the housing portion 70 when the filter assembly 20 is assembled. When the filter assembly 20 is assembled, a first seal is formed between the protrusion 52 (extending from the bottom surface of the sealing element 50) and the channel 72 of the housing portion 70, and a second seal is formed between the top surface of the sealing element 50 and the lid 30 such that the filter element 22 is at least partially contained within the filter housing assembly 28.

[0052] When the lid 30 is placed on top of the sealing element 50 (which is on top of the housing portion 70), the lid 30 forms the second seal with the top surface of the sealing element 50 and encloses at least one side of the housing portion 70. Accordingly, the lid 30 and the housing portion 70 enclose or contain at least a portion of the filter element 22.

[0053] The sealing element 50 comprises a self-aligning feature that comprises the protrusion 52 that extends or protrudes along the entire perimeter of the sealing element 50. With the channel 72, the protrusion 52 serves as a self-aligning feature to align the sealing element 50 and the housing portion 70. The protrusion 52 extends away from the bottom surface of the sealing element 50 such that, when the housing portion 70 and the sealing element 50 are attached, the protrusion 52 extends toward the housing portion 70. The protrusion 52 may extend from the bottom surface of the sealing element 50 along an axial direction of the filter assembly 20 away from the bottom surface of the sealing element 50,

where the axial direction may refer to the direction of fluid flow through the filter media 24 of the filter element 22. As described further herein, the shape of the protrusion 52 complements the shape of the channel 72 such the protrusion 52 fits within the channel 72.

[0054] The protrusion 52 fits within, engages with, sits within, and forms the first seal with the channel 72 of the housing portion 70, thereby aligning the housing portion 70 with the sealing element 50 and sealing the housing portion 70 and the sealing element 50. Due to the relative geometry of the protrusion 52 and the channel 72, the protrusion 52 is automatically and accurately centered within the channel 72 during assembly, which also centers the sealing element 50 to the housing portion 70 and creates a complete seal between the sealing element 50 and the housing portion 70, even if the sealing element 50 and the housing portion 70 are misaligned with each other during assembly.

[0055] The sealing element 50 may be a variety of different sealing materials, such as rubber or plastic.

[0056] Configurations of the Protrusion and the Channel

[0057] As shown in FIGS. 6-12B, the respective shape and size of the channel 72 and the protrusion 52 are complementary to each other such that the protrusion 52 fits within the channel 72. In order for the sealing element 50 to automatically align and center with the housing portion 70, the channel 72 and the protrusion 52 are angled or tapered along their respective heights such that one of both of the sides of the channel 72 and the protrusion 52 are angled or tapered (relative to the axial direction). For example, at least a portion of the channel 72 and the protrusion 52 may each have triangular cross-sectional shapes that are complementary to each other, as shown in FIG. 6. This configuration allows the protrusion 52 to slide into the channel 72, even if the protrusion 52 and the channel 72 (or the sealing element 50 and the housing portion 70) are misaligned.

[0058] The width of the channel 72 is relatively more wide at the top or entrance into the channel 72 and is relatively more narrow at the base or bottom of the channel 72 than the width at the top of the channel 72. Accordingly, the width of the protrusion 52 is relatively narrower at the tip or end of the protrusion 52 (than the width at the base of the protrusion 52) and is relatively wider at the base or bottom of the protrusion 52 in order to fit within and complement the geometry of the channel 72.

[0059] The channel 72 and the protrusion 52 may each have particular shapes such that other channels or features will not fit with the channel 72 or the protrusion 52. For example, as shown in FIGS. 7A-7B, the channel 72 and/or the protrusion 52 may not seal with other channels or features that do not have the correct complementary shape.

[0060] The channel 72 and the protrusion 52 may have a variety of different complementary shapes that increases the complexity of the interface between the channel 72 and the protrusion 52 and provides the possibility for engine integrity protection (EIP), as shown, for example, in FIGS. 7A-7B, 8A-8B, and 9A-9B. According to one embodiment, at least a portion of the cross-sectional shapes of the channel 72 and the protrusion 52 may be trapezoidal, where at least a portion of the sides of the channel 72 and the protrusion 52 are angled and a top surface of the base of the channel 72, and a top surface of the tip of the protrusion 52 are flat and substantially perpendicular to an axial direction of the filter assembly.

[0061] According to one embodiment as shown in FIGS. 7A-7B, the base or bottom of the channel 72 has a rectangular-shaped pocket 74 (taken in the cross-section of the channel 72) and the tip or end of the protrusion 52 accordingly has a complementary rectangular-shaped end 54 (taken in the cross-section of the protrusion 52). Accordingly, a portion of the sides of the channel 72 proximate the base of the channel 72 are straight (relative to the angled sides of the channel 72) and substantially perpendicular to the base of the channel 72. Further, a portion of the sides of the protrusion 52 proximate the tip of the protrusion 52 are straight (relative to the angled sides of the protrusion 52) and substantially perpendicular to the tip of the protrusion 52.

[0062] According to one embodiment as shown in FIGS. 8A-8B, the tip or end of the protrusion 52 has an inverted v-shaped groove, channel, or recess 56 and the base or bottom of the channel 72 has a v-shaped bump or extension 76 that is complementary to and fits within the recess 56 of the protrusion 52 when the protrusion 52 is positioned within the channel 72. The recess 56 of the protrusion 52 extends into the body of the protrusion 52 (i.e., toward the bottom surface of the sealing element 50), and the extension 76 of the channel 72 extends up from the upper surface of the channel 72.

[0063] According to another embodiment as shown in FIGS. 9A-9B, the protrusion 52 includes side ribs 58 that extend from the base (e.g., from the bottom surface of the sealing element 50) to the tip or end of the protrusion 52 and on either side of the protrusion 52. The side ribs 58 extend from the sides of the protrusion 52 and increase the width of the protrusion 52 in the areas of the protrusion 52 that the side ribs 58 are located. Additionally, as shown in FIG. 9B, the tip of the protrusion 52 may not follow in line with the taper of the rest of the protrusion 52 (along its cross-section) such that the tip that is slightly wider (compared to if the tip had followed the taper of the rest of the protrusion 52). For example, the tip of the protrusion 52 is wider than an area of the protrusion 52 proximate the tip along the length of the protrusion 52. Accordingly, the width of the base of the channel 72 may be slightly smaller than the width of the tip of the protrusion 52 in order in order to ensure a complete seal between the protrusion 52 and the channel 72. Furthermore, the tip of the protrusion 52 may be rounded such that the end of the protrusion 52 is rounded.

[0064] As shown in FIGS. 10A-12B, the angle of the tapers for each of the protrusion 52 and the channel 72 may vary depending on the desired configuration, seal, and ease of alignment. For example, as shown in FIGS. 10A-10B, the angle of the tapers may be approximately 45°. Alternatively, as shown in FIGS. 11A-11B, the angle of the tapers may be approximately 60°. According to yet another embodiment as shown in FIGS. 12A-12B, the angle of the tapers may be approximately 70°.

[0065] According to one embodiment, the width near the base of the protrusion 52 along the taper (i.e., the angled sides of the protrusion 52) may be less than the width near the entrance into or the top of the channel 72 along the taper (i.e., the angled sides of the channel 72) in order to provide extra room between the protrusion 52 and the channel 72 to allow the protrusion 52 to easily slide into the channel 72 and align the sealing element 50 with the housing portion 70. As shown in FIG. 6, for example, a width at a top of the channel 72 is wider than a width at a base of the protrusion 52 such that there is a gap or space between the sides or walls of the channel 72 and the sides or walls of the protrusion 52 (on either or both sides of the protrusion 52) when the protrusion 52 is fully positioned within the channel 72. Accordingly, the protrusion 52 and the channel 72 do not have an approximately perfect interference fit. Otherwise, with a perfect interference fit between

the protrusion 52 and the channel 72, it may be difficult for the protrusion 52 to slide into and fit within the channel 72. The width near the tip of the protrusion 52, however, may be approximately equal to the width near the base of the channel 72 in order to ensure a complete seal between the sealing element 50 and the housing portion 70.

[0066] Due to the configuration of the channel 72 and the protrusion 52, the channel 72 may be higher than channels previous filter assemblies, which may increase the effectiveness of the seal between the housing portion 70 and the sealing element 50. Accordingly, the protrusion 52 may also be higher in order to accommodate the size of the channel 72.

[0067] As utilized herein, the terms “about,” “approximately,” “substantially,” and similar terms are intended to have a broad meaning in harmony with the common and accepted usage by those of ordinary skill in the art to which the subject matter of this disclosure pertains. It should be understood by those of skill in the art who review this disclosure that these terms are intended to allow a description of certain features described and claimed without restricting the scope of these features to the precise numerical ranges provided. Accordingly, these terms should be interpreted as indicating that insubstantial or inconsequential modifications or alterations of the subject matter described and claimed are considered to be within the scope of the invention as recited in the appended claims.

[0068] The terms “coupled,” “connected,” “attached,” and the like as used herein mean the joining of two members directly or indirectly to one another. Such joining may be stationary (e.g., permanent) or moveable (e.g., removable or releasable). Such joining may be achieved with the two members or the two members and any additional intermediate members being integrally formed as a single unitary body with one another or with the two members or the two members and any additional intermediate members being attached to one another.

[0069] References herein to the positions of elements (e.g., “top,” “bottom,” “above,” “below,” etc.) are merely used to describe the orientation of various elements in the FIGURES. It should be noted that the orientation of various elements may differ according to other exemplary embodiments, and that such variations are intended to be encompassed by the present disclosure.

[0070] It is important to note that the construction and arrangement of the various exemplary embodiments are illustrative only. Although only a few embodiments have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter described herein. For example, elements shown as integrally formed may be constructed of multiple parts or elements, the position of elements may be reversed or otherwise varied, and the nature or number of discrete elements or positions may be altered or varied. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. Other substitutions, modifications, changes and omissions may also be made in the design, operating conditions and arrangement of the various exemplary embodiments without departing from the scope of the present invention.

WHAT IS CLAIMED IS:

1. A filter assembly comprising:
a housing assembly comprising a housing portion and a lid, the housing assembly sized for containing at least a portion of a filter element, the housing portion comprising a channel formed in an upper surface thereof; and
a sealing element comprising a top surface, a bottom surface, and a protrusion extending away from the bottom surface, the protrusion fitting within and forming a first seal with the channel, thereby aligning the housing portion with the sealing element and sealing the sealing element and the housing portion,
wherein the lid forms a second seal with the top surface of the sealing element and encloses at least one side of the housing portion such that the lid and the housing portion contain at least the portion of the filter element when installed.
2. The filter assembly of claim 1, wherein a width at a base of the channel is narrower than a width at a top of the channel and a width at a tip of the protrusion is narrower than a width at a base of the protrusion.
3. The filter assembly of claim 1, wherein a width at a top of the channel is wider than a width at a base of the protrusion such that there is a gap between the channel and the protrusion when the protrusion is positioned within the channel.
4. The filter assembly of claim 1, wherein the shape and size of the channel and the protrusion are complementary to each other.
5. The filter assembly of claim 1, wherein the channel and the protrusion are tapered along their respective heights.
6. The filter assembly of claim 1, wherein a portion of the protrusion has a triangular cross-section.
7. The filter assembly of claim 1, wherein at least a portion of respective sides of the channel and the protrusion are angled and a top surface of a base of the channel and a top surface of a tip of the protrusion are substantially perpendicular to an axial direction of the filter assembly.

8. The filter assembly of claim 7, wherein a portion of the sides of the channel proximate the base of the channel are substantially perpendicular to the base of the channel.

9. The filter assembly of claim 1, wherein a tip of the protrusion comprises a recess and a base of the channel comprises an extension that fits within the recess of the protrusion when the protrusion is positioned within the channel.

10. The filter assembly of claim 1, wherein the protrusion comprises side ribs that extend from a base of the protrusion to an area proximate to a tip of the protrusion.

11. The filter assembly of claim 1, wherein a tip of the protrusion is wider than an area of the protrusion that is proximate the tip along the length of the protrusion.

12. The filter assembly of claim 1, further comprising a diaphragm that comprises the sealing element.

13. The filter assembly of claim 1, further comprising a rim that comprises the sealing element.

14. The filter assembly of claim 13, wherein the rim comprises an opening that extends through the center of the rim and allows fluid to flow through the sealing element.

15. The filter assembly of claim 1, wherein the sealing element does not include an opening that extends through the sealing element such that fluid cannot flow through the sealing element.

16. The filter assembly of claim 1, wherein a perimeter of the sealing element substantially matches a perimeter of the channel of the housing portion.

17. The filter assembly of claim 1, wherein the protrusion extends along an entirety of the perimeter of the sealing element.

18. The filter assembly of claim 1, wherein the protrusion extends from the bottom surface of the sealing element along an axial direction of the filter assembly, and wherein fluid flows through the filter element along the axial direction.

19. A filter assembly comprising:

a filter element comprising a filter media for filtering a fluid;
a housing assembly comprising a housing portion and a lid, the housing assembly containing at least a portion of the filter element, the housing portion comprising a channel formed in an upper surface thereof; and
a sealing element comprising a top surface, a bottom surface, and a protrusion extending away from the bottom surface, the protrusion fitting within and forming a first seal with the channel, thereby aligning the housing portion with the sealing element and sealing the sealing element and the housing portion,
wherein the lid forms a second seal with the top surface of the sealing element and encloses at least one side of the housing portion such that the lid and the housing portion contain at least the portion of the filter element.

20. The filter assembly of claim 19, wherein a width at a base of the channel is narrower than a width at a top of the channel and a width at a tip of the protrusion is narrower than a width at a base of the protrusion.

21. The filter assembly of claim 19, wherein the filter element comprises the sealing element.

22. The filter assembly of claim 1, further comprising a diaphragm that comprises the sealing element.

23. The filter assembly of claim 1, further comprising a rim that comprises the sealing element.

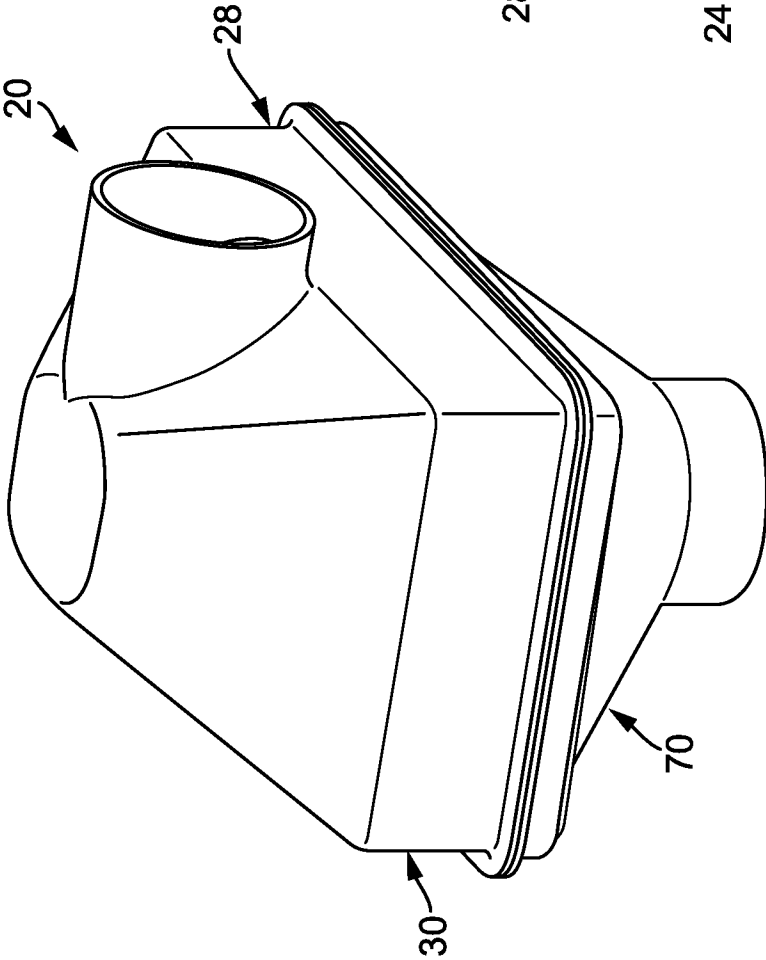


FIG. 1A

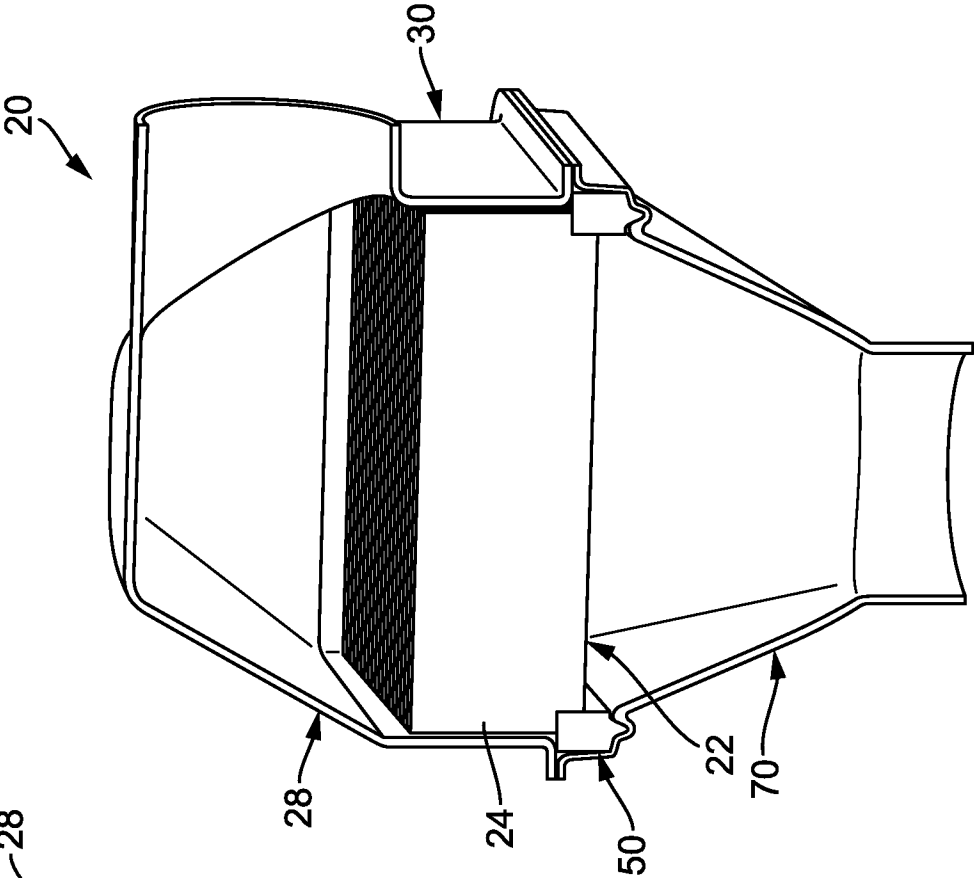


FIG. 1B

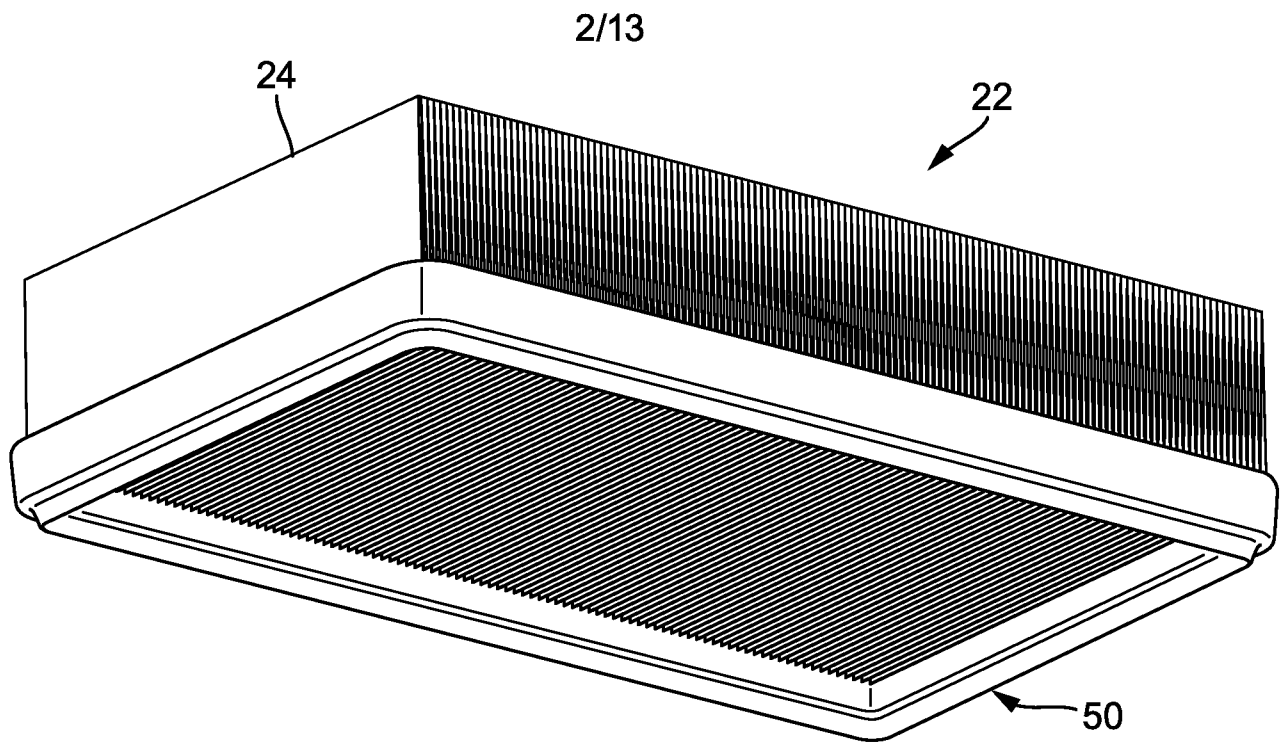


FIG. 2A

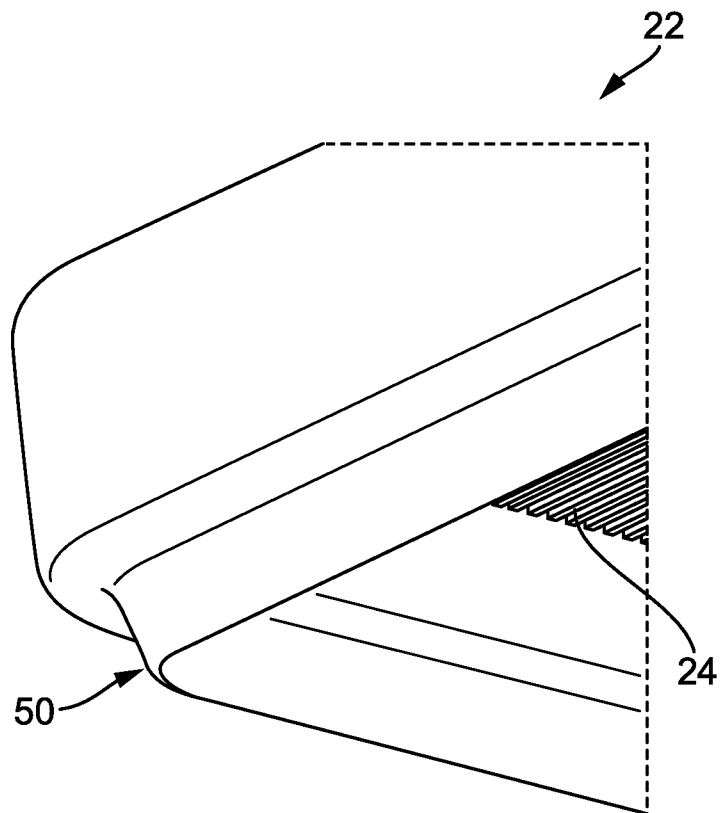


FIG. 2B

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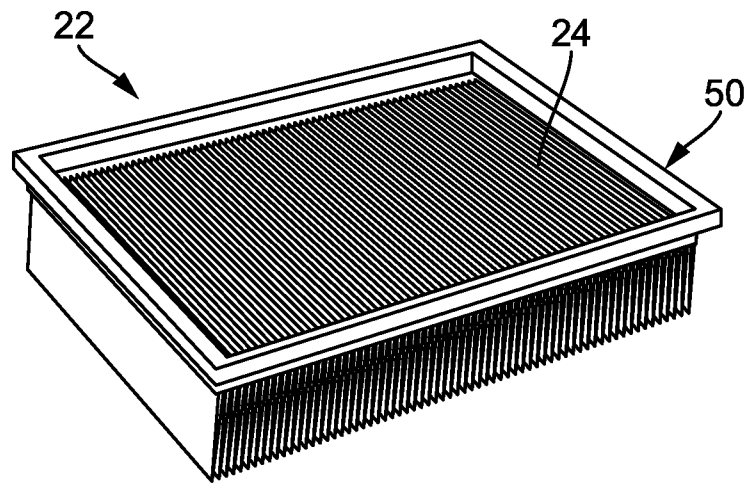


FIG. 3A

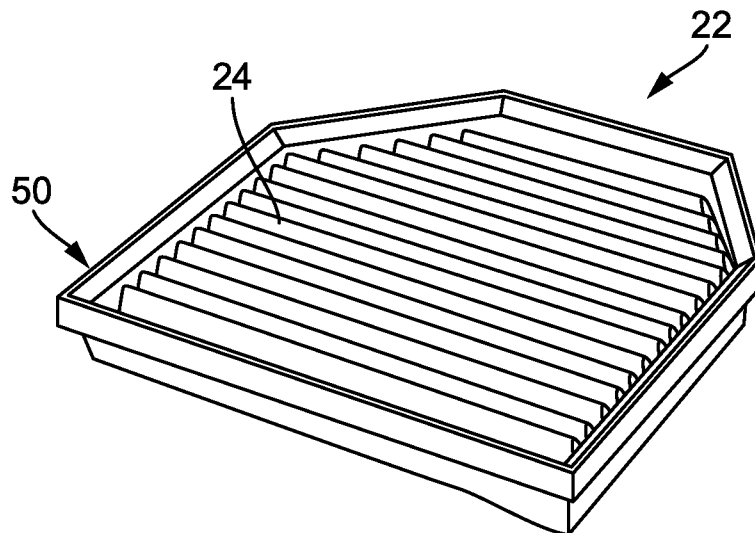


FIG. 3B

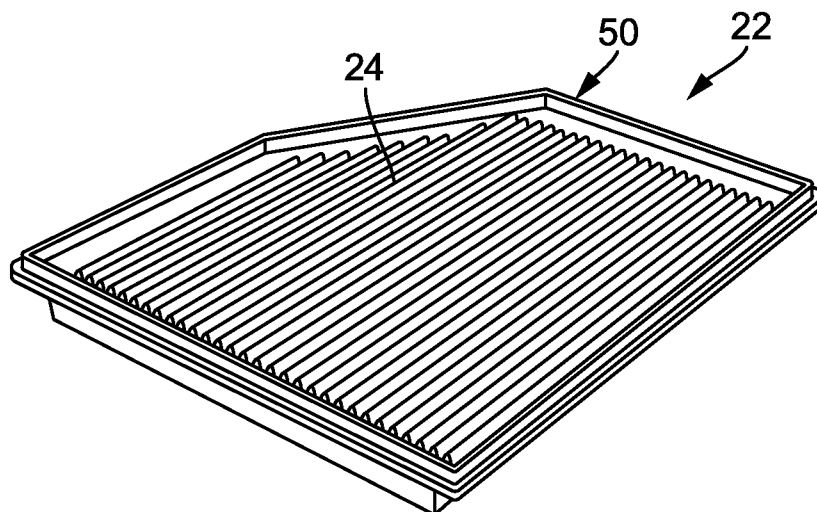


FIG. 3C

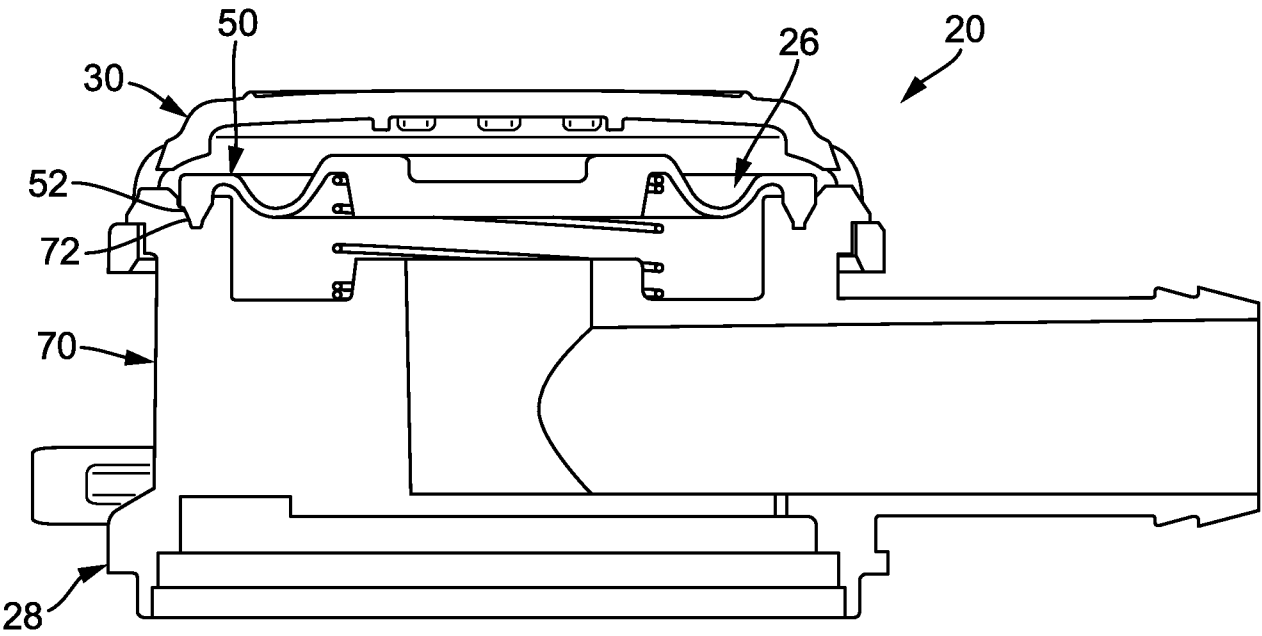


FIG. 4

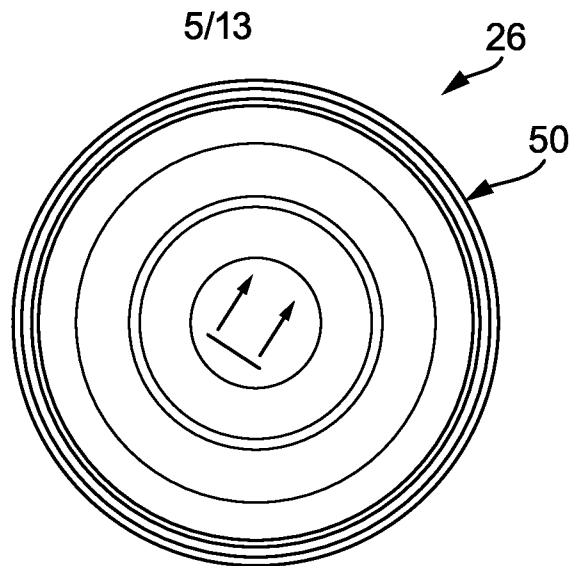


FIG. 5A

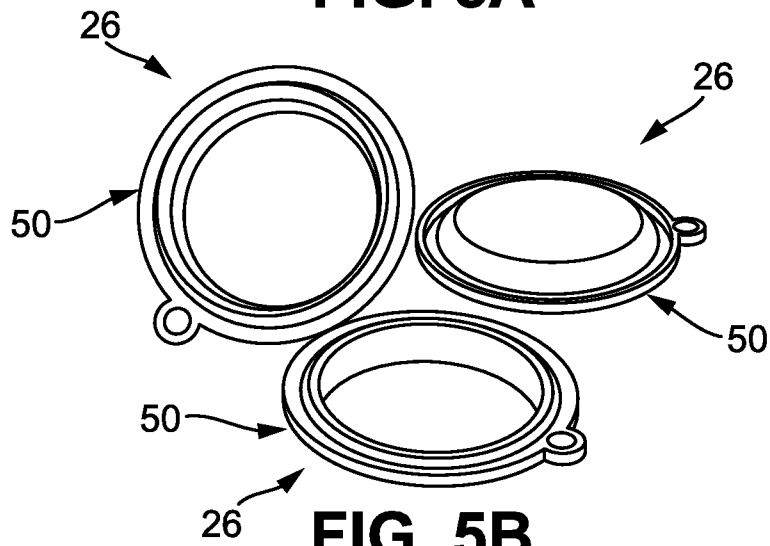


FIG. 5B

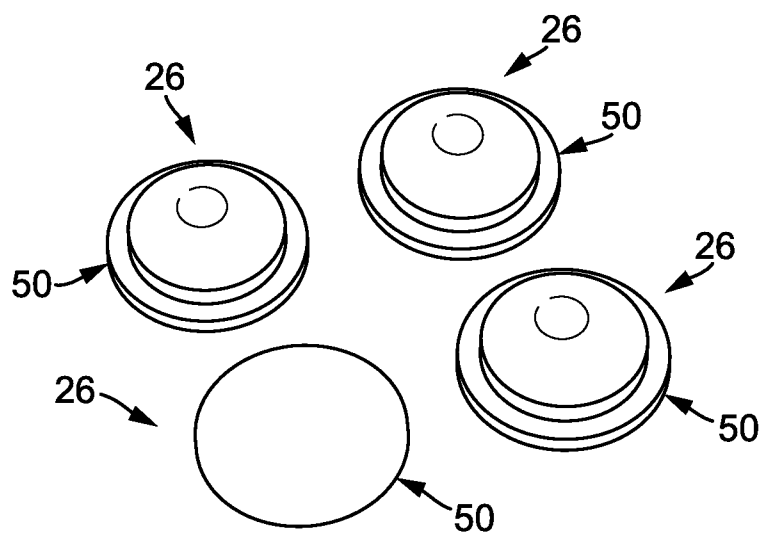


FIG. 5C

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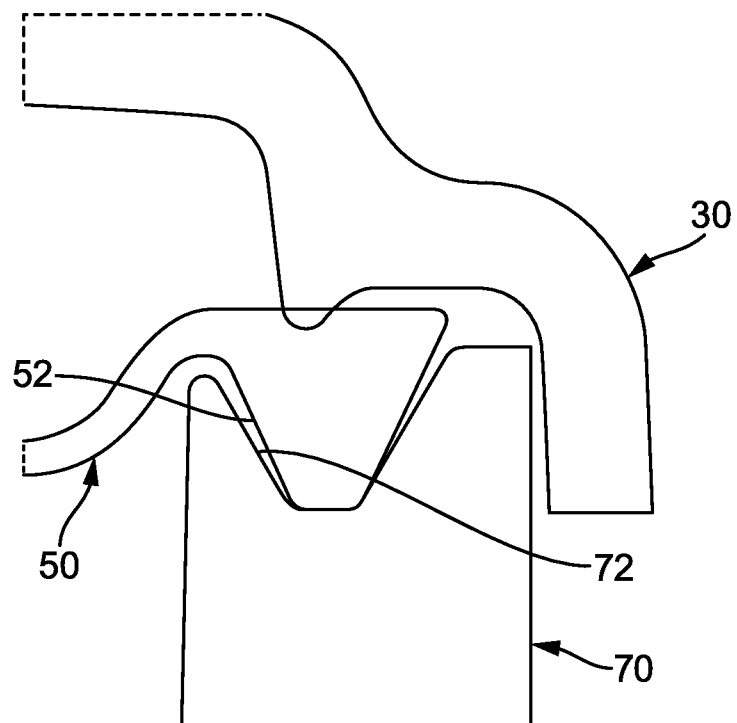


FIG. 6

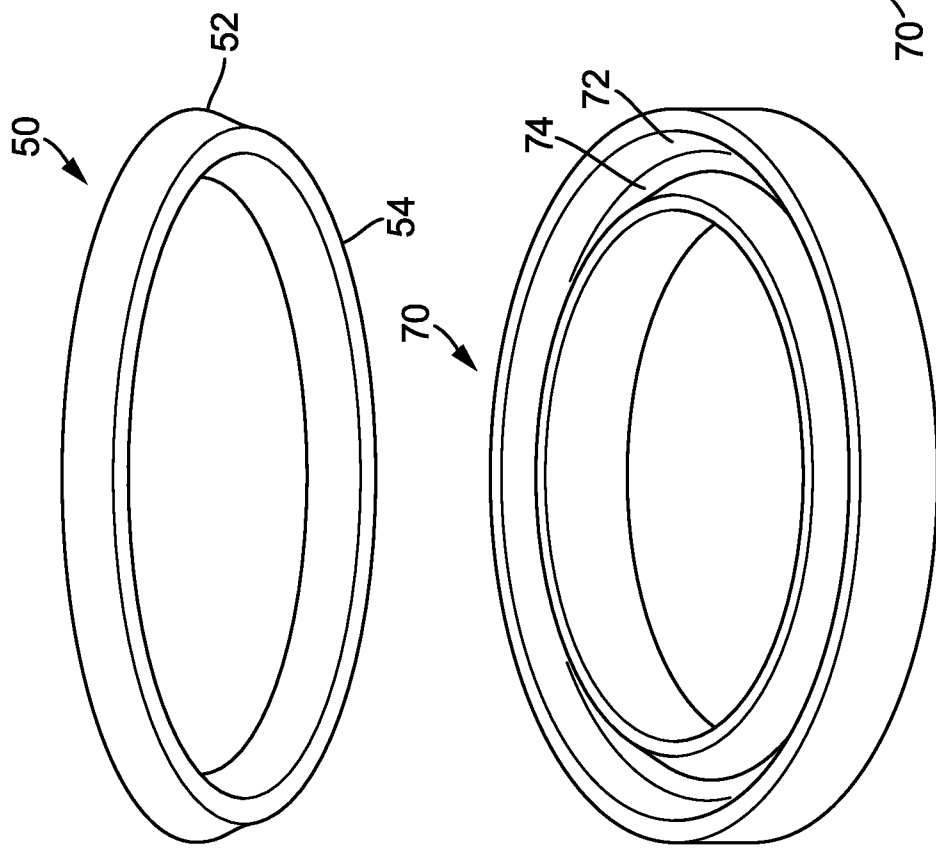


FIG. 7A

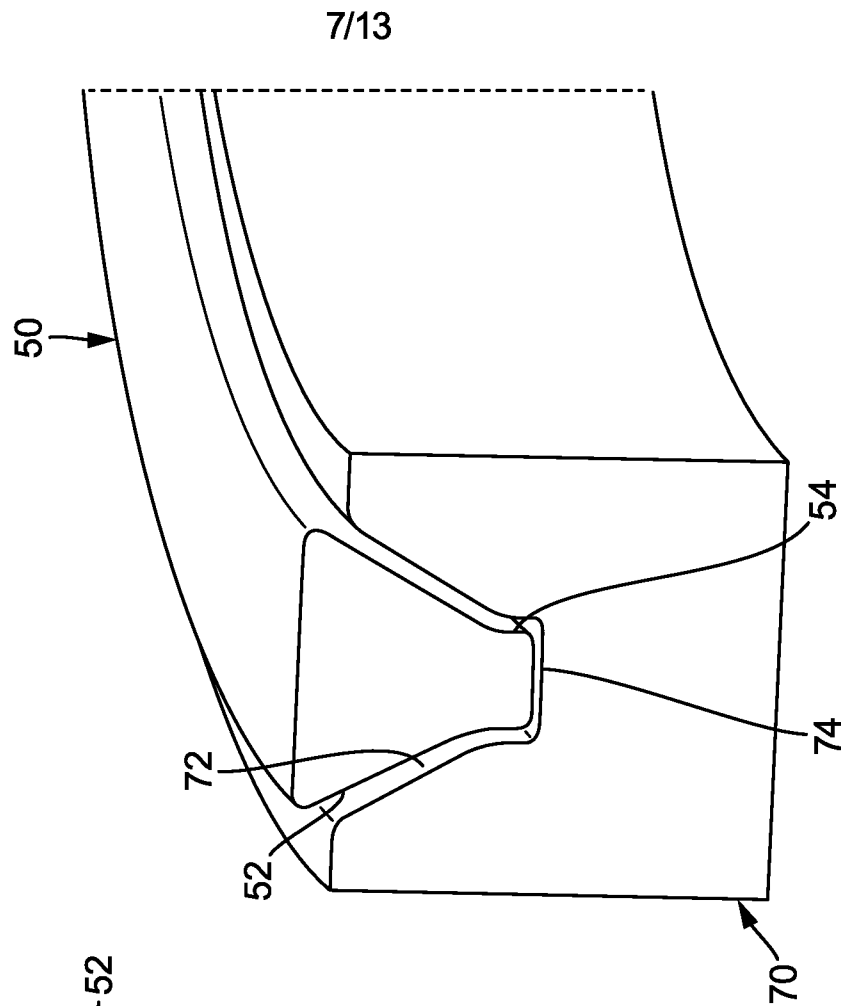


FIG. 7B

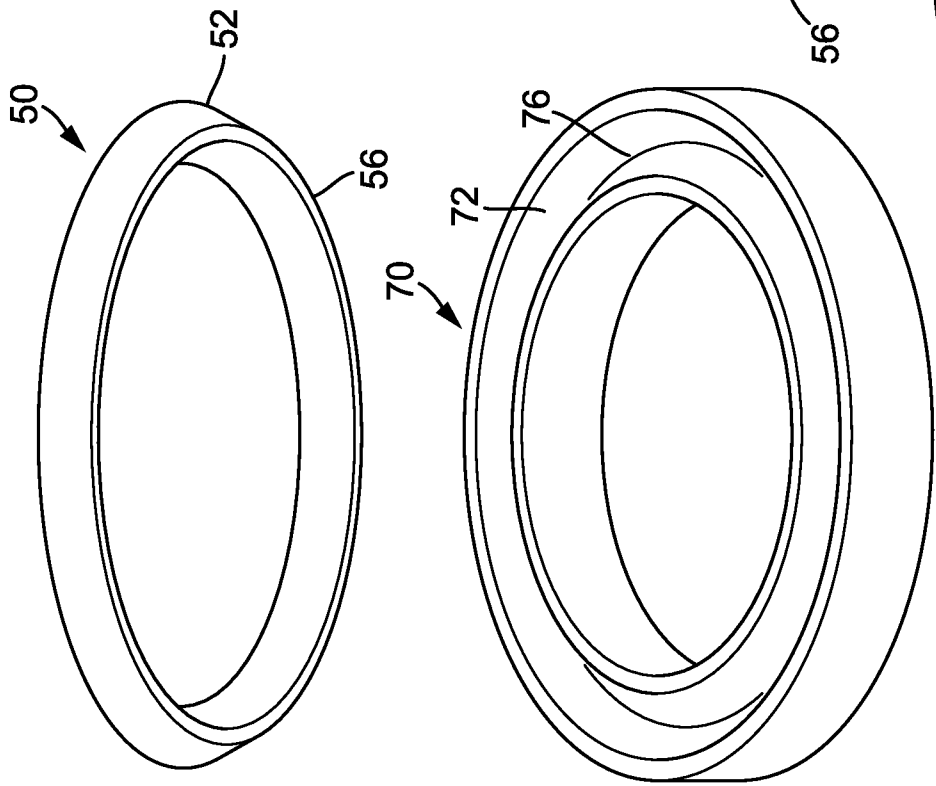


FIG. 8A

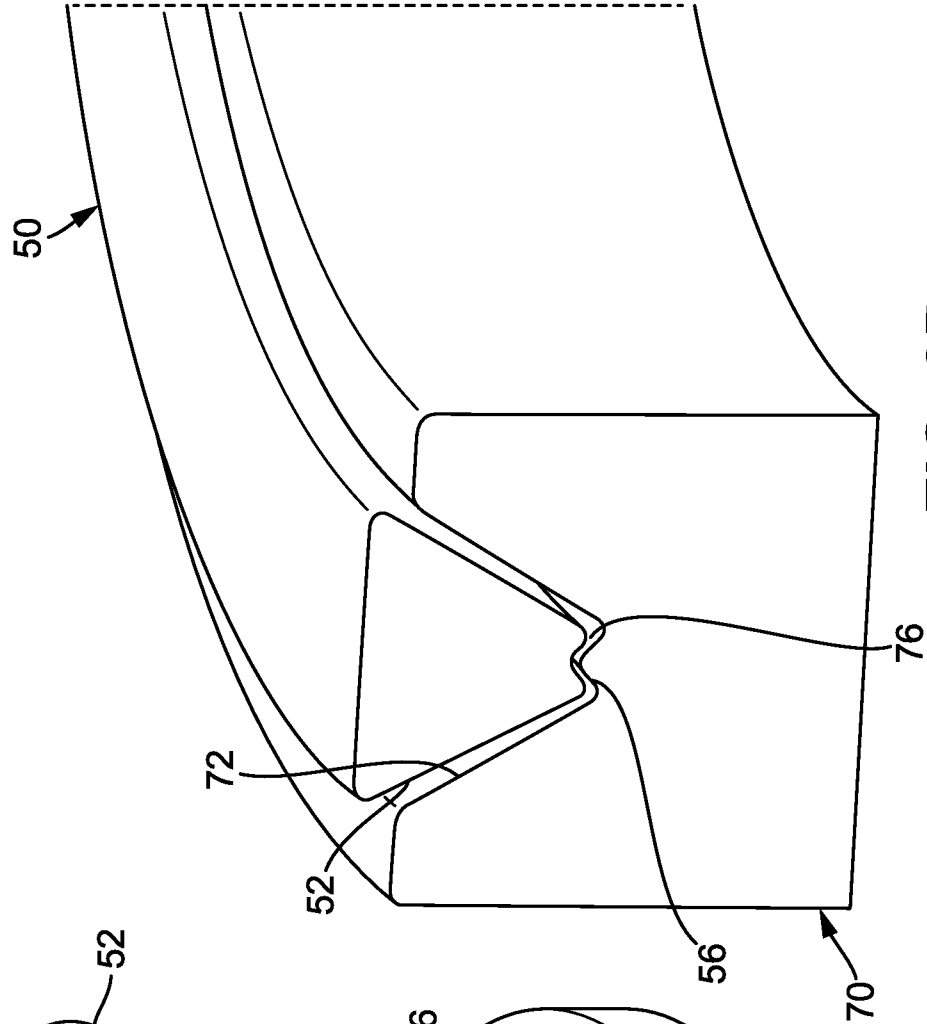


FIG. 8B

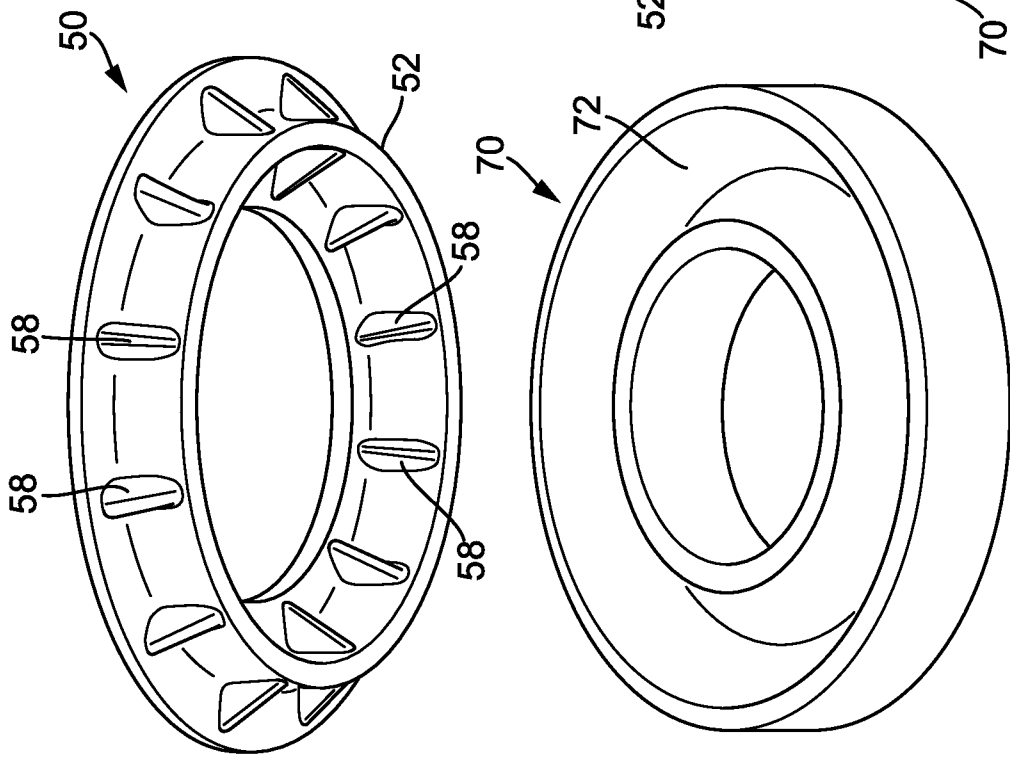


FIG. 9A

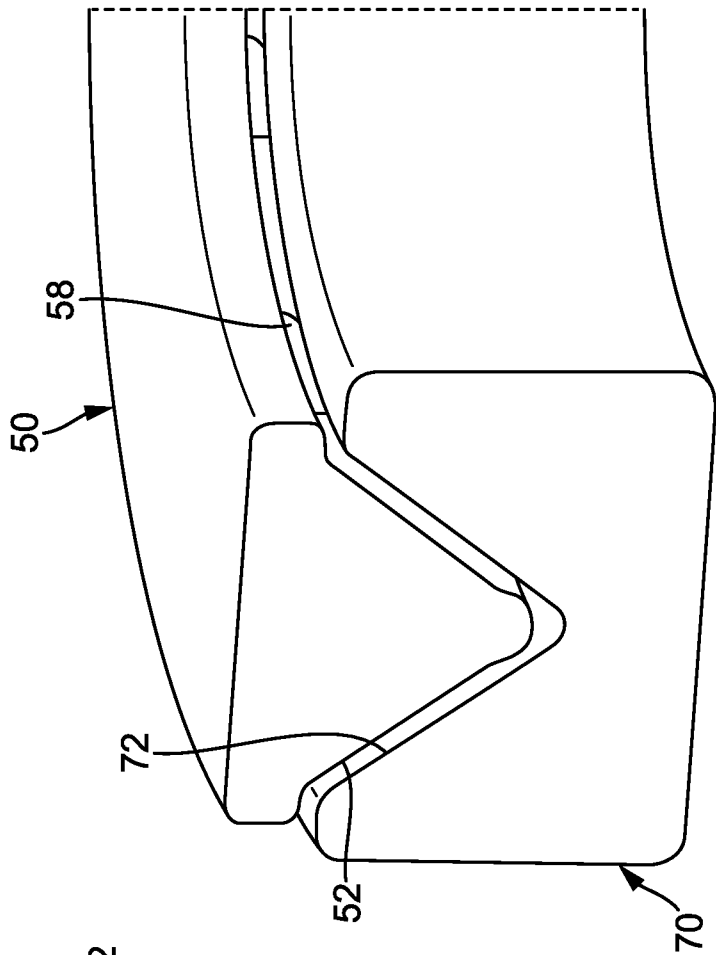


FIG. 9B

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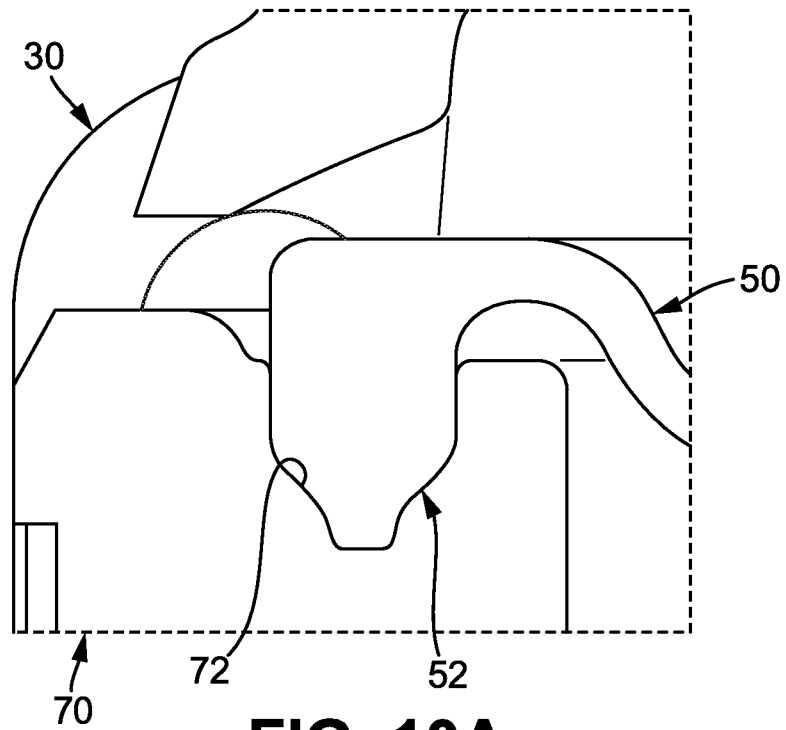


FIG. 10A

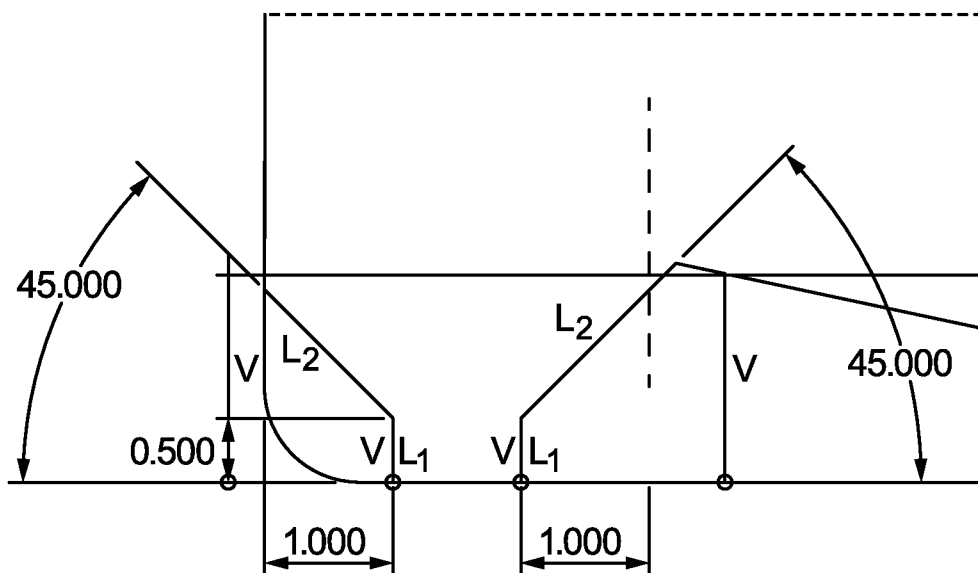


FIG. 10B

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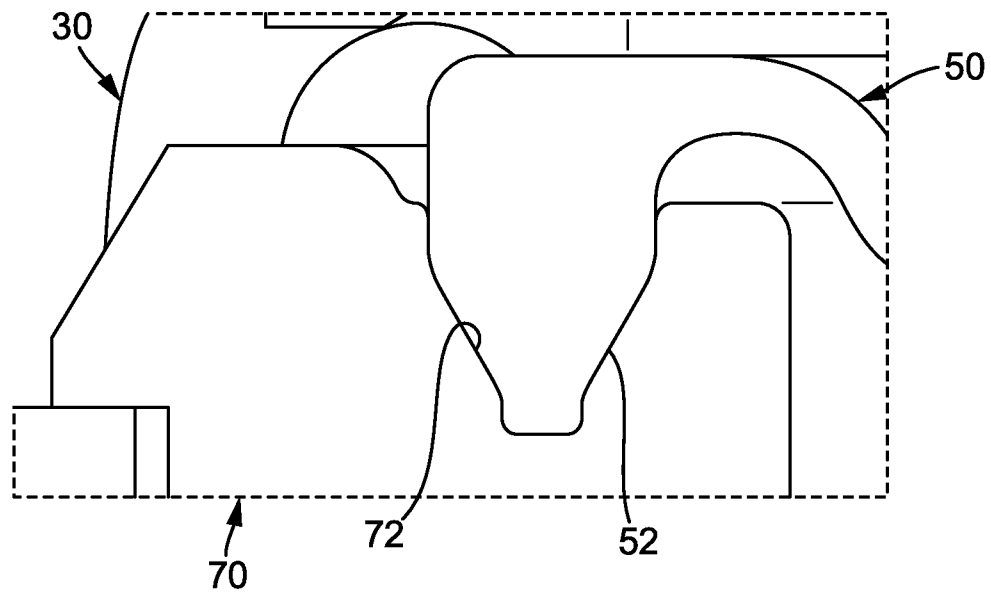


FIG. 11A

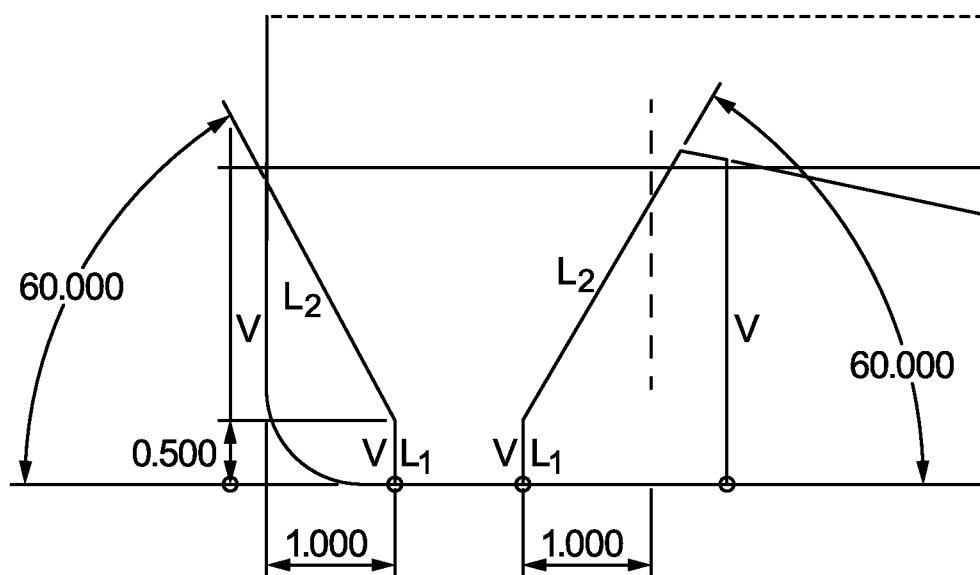


FIG. 11B

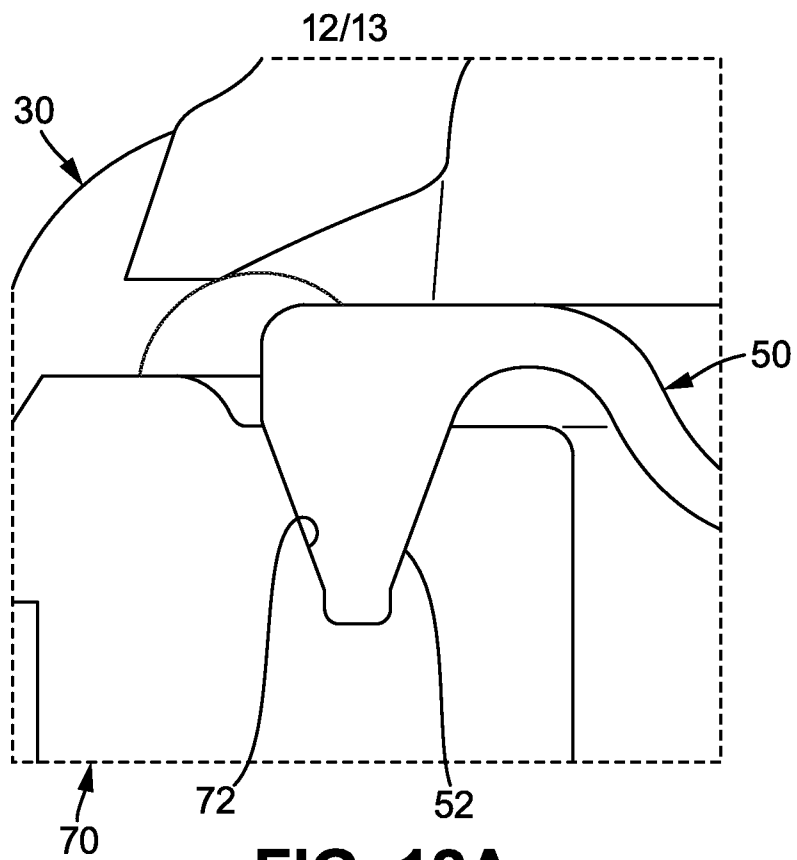


FIG. 12A

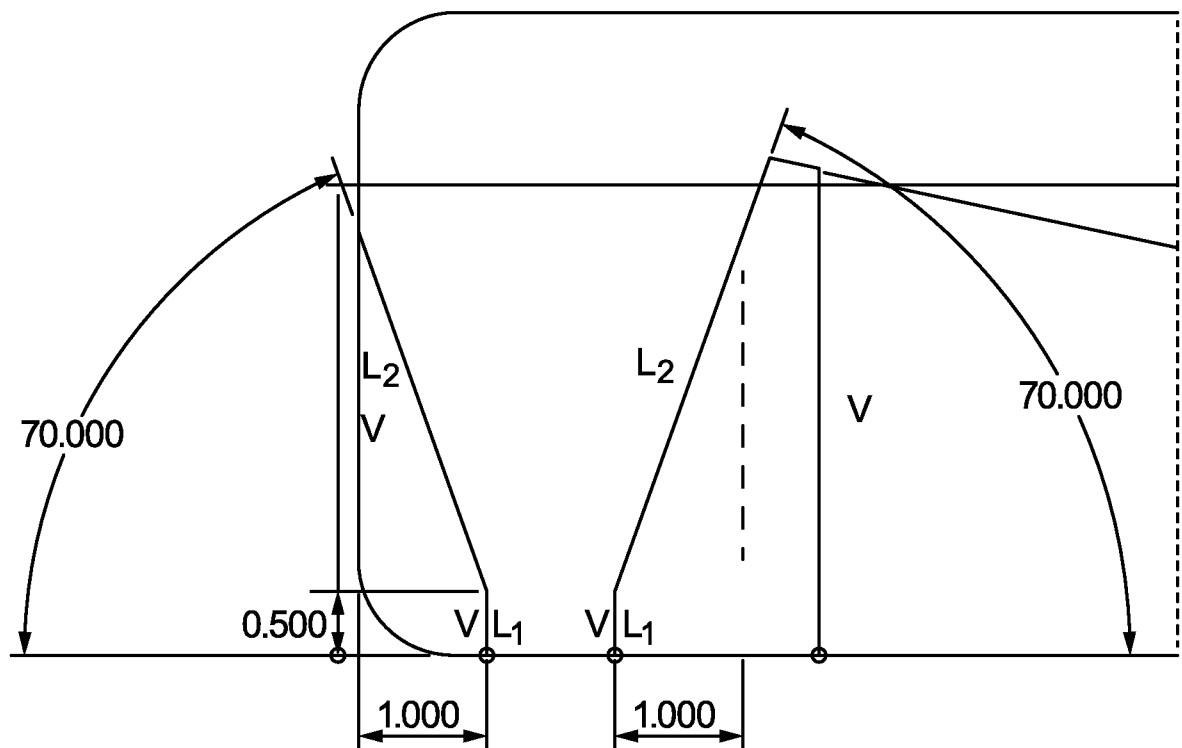


FIG. 12B

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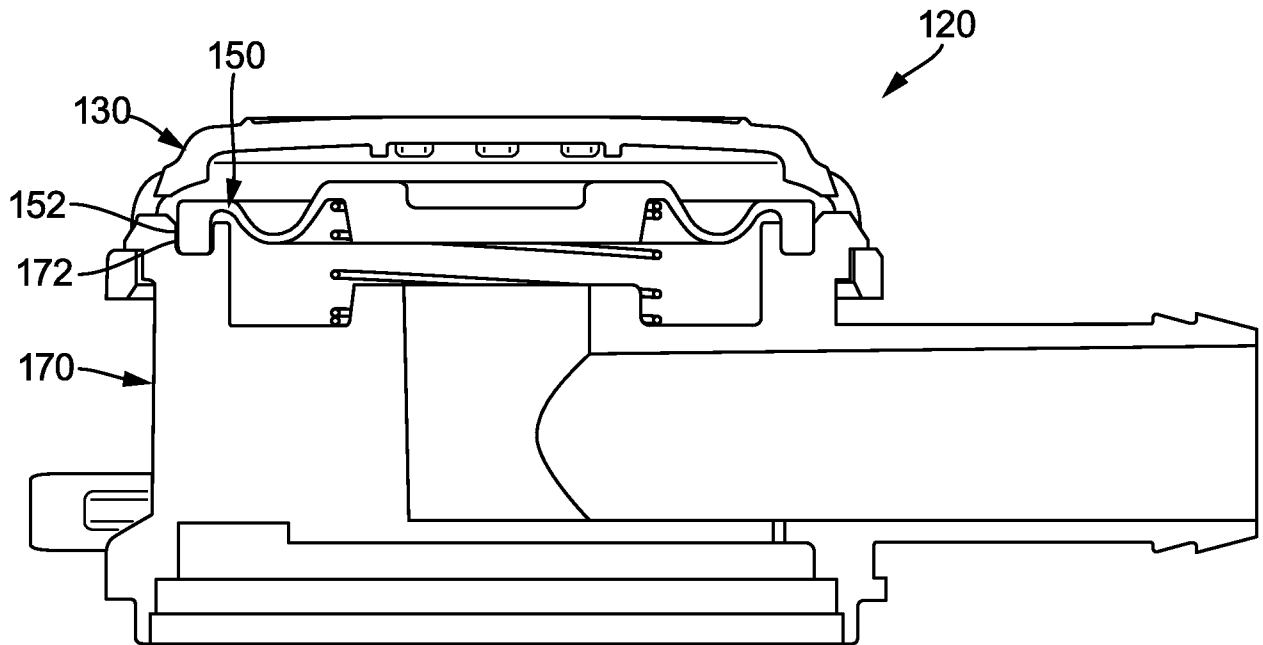


FIG. 13

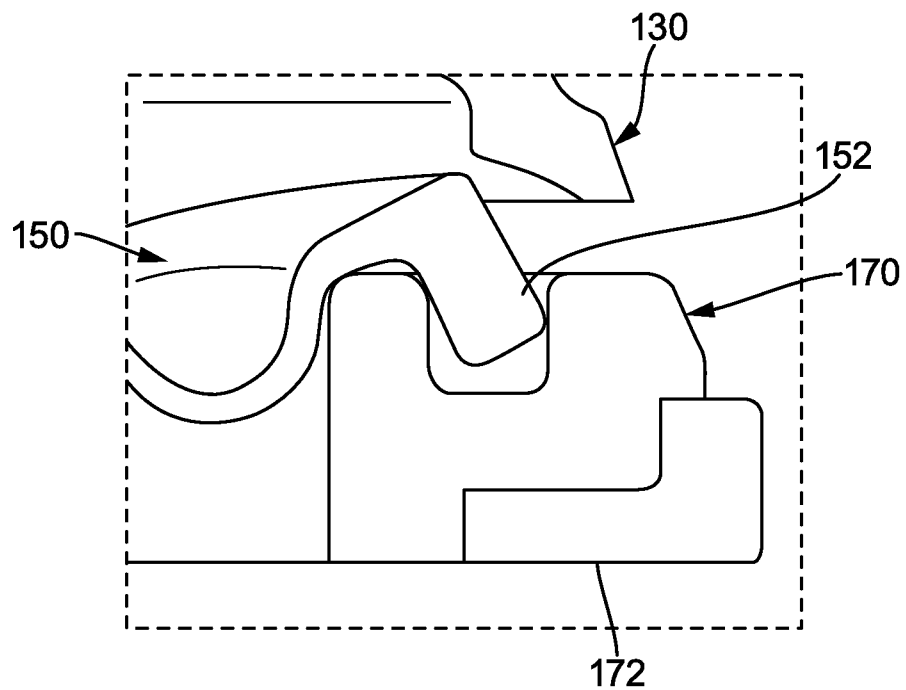


FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 17/56288

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B01D 27/08, B01D 35/30; F02M 35/024 (2017.01)

CPC - B01D 27/08, B01D 35/306, B01D 27/00, B01D 29/00, B01D 35/00, B01D 35/005, B01D 35/30, B01D 46/0002, B01D 46/0005, B01D 46/0009, B01D 46/0015, B01D 2271/02, B01D 2271/022; F02M35/024, F02M35/02416

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)

See Search History Document

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

See Search History Document

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

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2015/0020489 A1 (Mann + Hummel GMBH) 22 January 2015 (22.01.2015), Figs. 1-2, para [0026]-[0029]	1-8, 11-13 and 15-23 ----- 10 and 14
X	US 2016/0045848 A1 (Donaldson Company Inc.) 18 February 2016 (18.02.2016), Figs. 18-18B, para [0284]-[0288]	1 and 9
Y	US 2006/0080949 A1 (Moriyama et al.) 20 April 2006 (20.04.2006), Fig. 4A, para [0027]	10
Y	US 3,223,612 A (William Kwo-Wei chen et al.) 14 December 1965 (14.12.1965), Fig. 2A, col. 6, ln. 41-49	14
A	US 2011/0167776 A1 (Gorg et al.) 14 July 2011 (14.07.2011), Figs. 2-8, para [0045]-[0054]	1-23
A	WO 2016/116793 A1 (Officine Metallurgiche G. Cornaglia SPA) 28 July 2016 (28.07.2016), Figs. 8-9, pg. 8, ln. 17 - pg. 9, ln. 10	1-23

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search

30 November 2017

Date of mailing of the international search report

05 JAN 2018

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