US010105557B1

(12) **United States Patent**
Yurechko et al.

(10) **Patent No.: US 10,105,557 B1**
(45) **Date of Patent: Oct. 23, 2018**

(54) **VALVE/CONNECTION SYSTEM TO PREVENT DOWNSTREAM CONTAMINATION FROM AN UPSTREAM SOURCE WHILE REPLACING FILTERS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 948 days.

(21) Appl. No.: **14/533,256**

(22) Filed: **Nov. 5, 2014**

Related U.S. Application Data

(60) Provisional application No. 61/900,699, filed on Nov. 6, 2013.

(51) **Int. Cl.**
A62B 18/10 (2006.01)
A62B 9/04 (2006.01)
A62B 23/02 (2006.01)

(52) **U.S. Cl.**
CPC ***A62B 18/10*** (2013.01); ***A62B 9/04*** (2013.01); ***A62B 23/02*** (2013.01)

(58) **Field of Classification Search**
CPC A62B 18/10; A62B 9/04; A62B 23/02
See application file for complete search history.

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(57) **ABSTRACT**

The present invention provides an improved filter connection system for a gas mask, comprising: a filter, a mounting means that attaches the filter to the gas mask, and a retainer means to hold the filter within the mounting means. The mounting means includes a protruding means; a valving assembly in communication with the protruding means, wherein the valving assembly enables air to flow from the fitter to the mask when the retainer means retains the protruding means, and disables air flow from the filter to the mask when the protruding means disengages from the retainer means; and a sealing means located within or adjacent to the valving assembly to prevent air from outside of the filter from entering the mounting means.

10 Claims, 14 Drawing Sheets

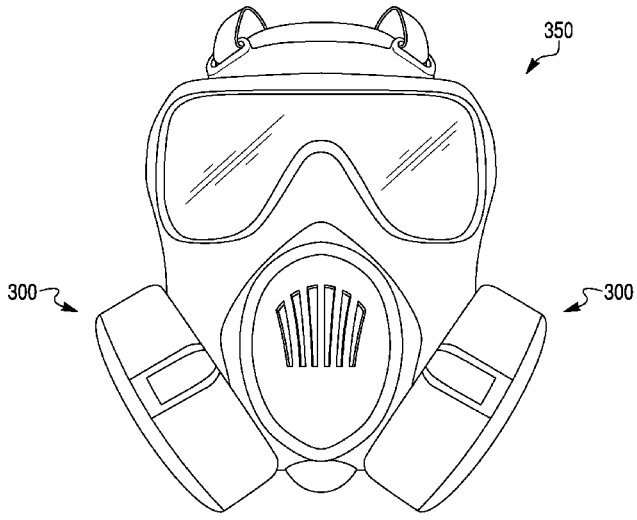
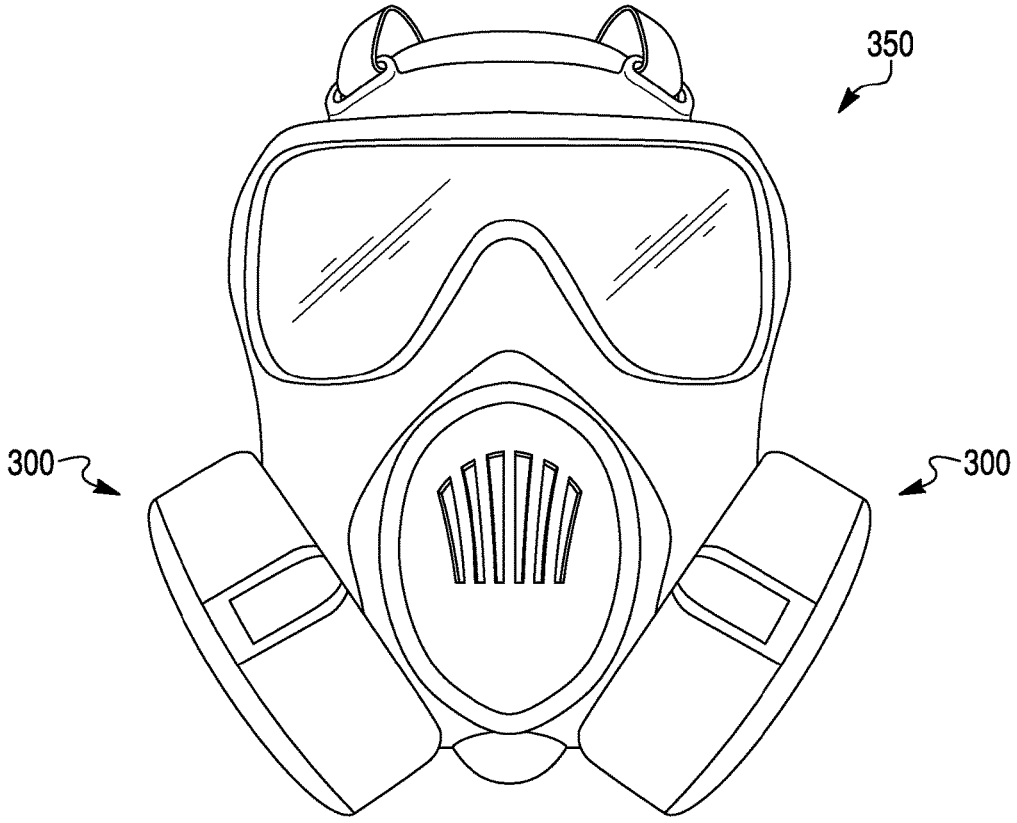


Fig. 1



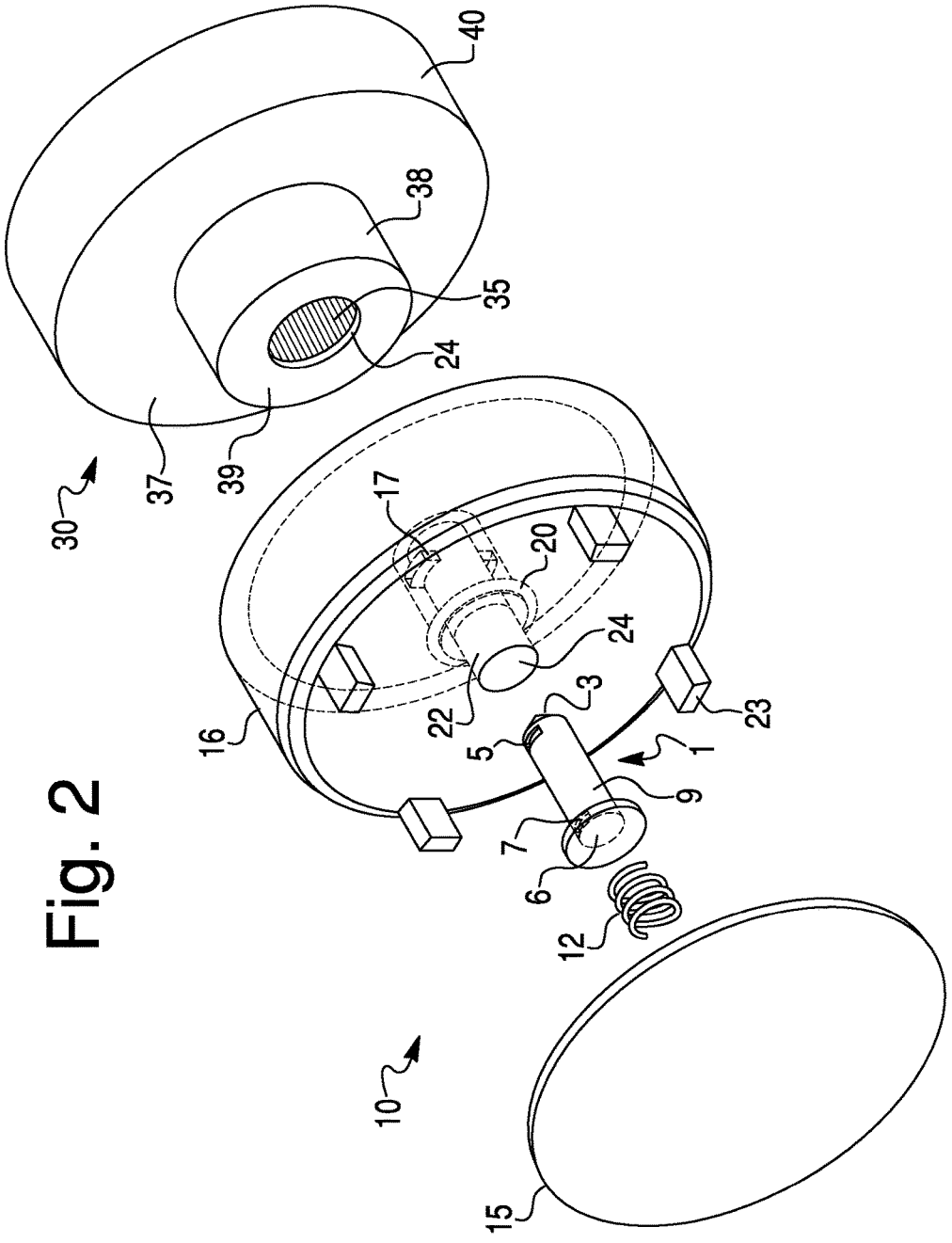
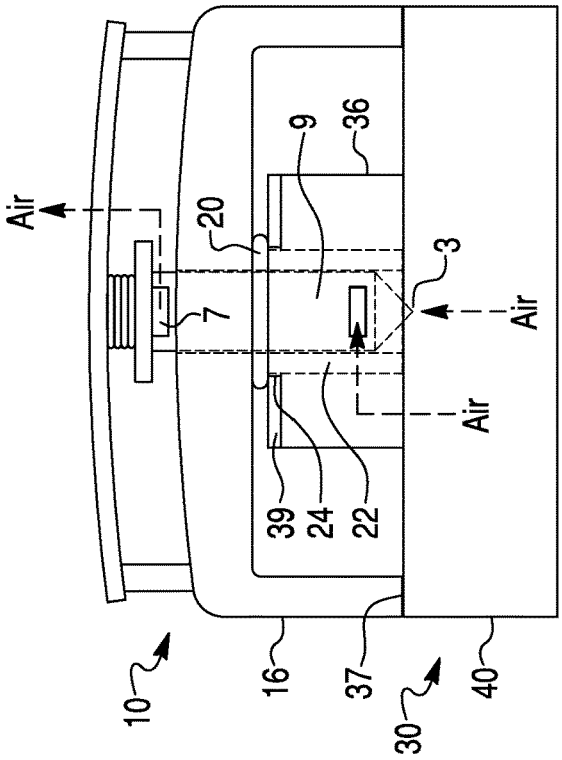


Fig. 2

Fig. 3B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20
9
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3
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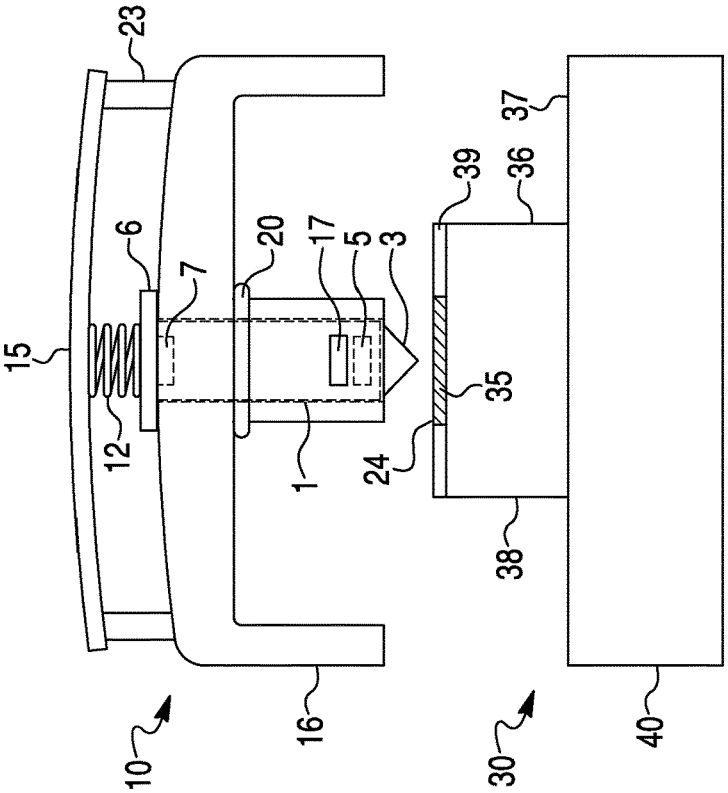
39
24
22
10
16
37
30
40

Fig. 3A


23
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3
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30
40

Fig. 4

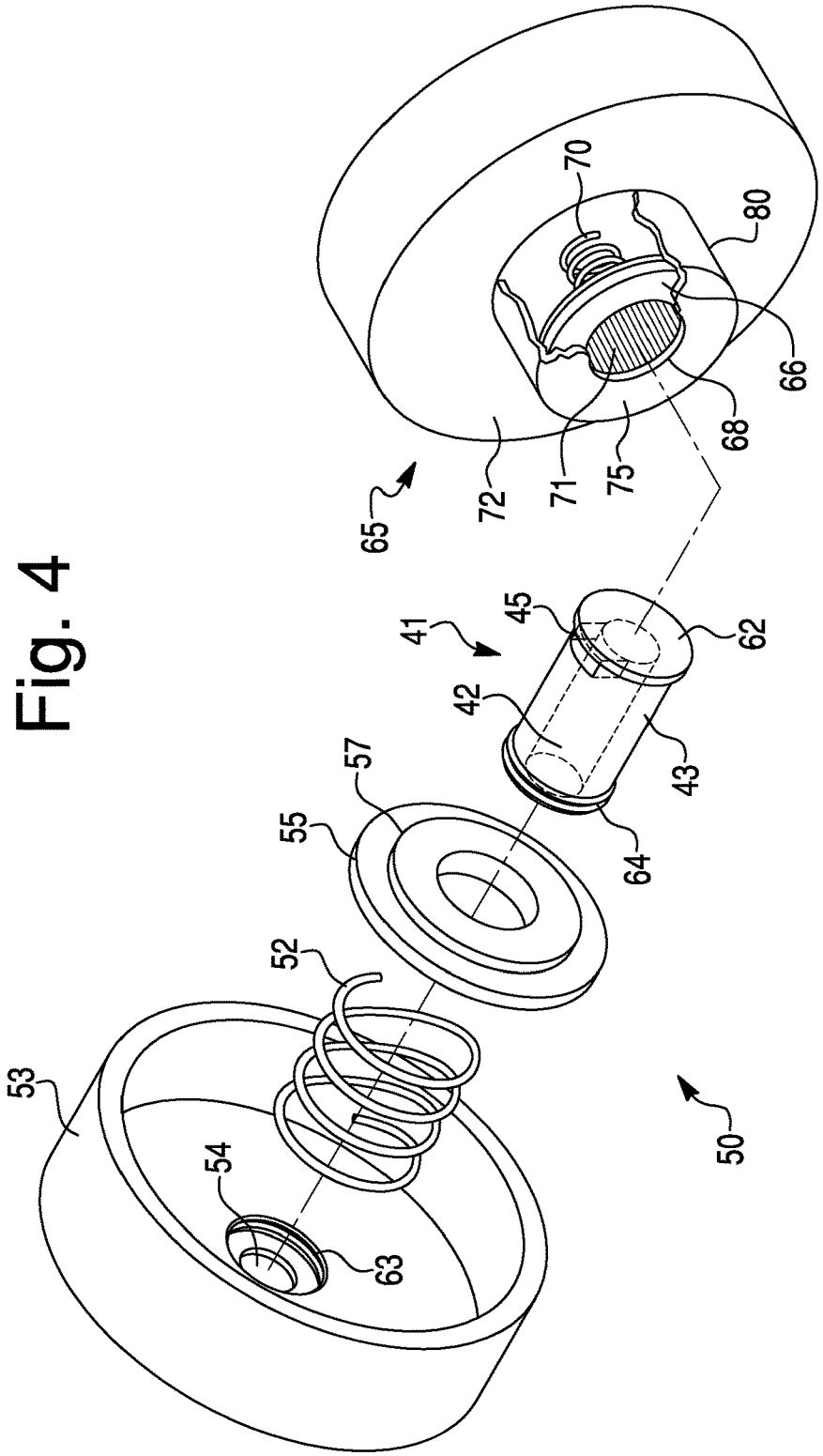
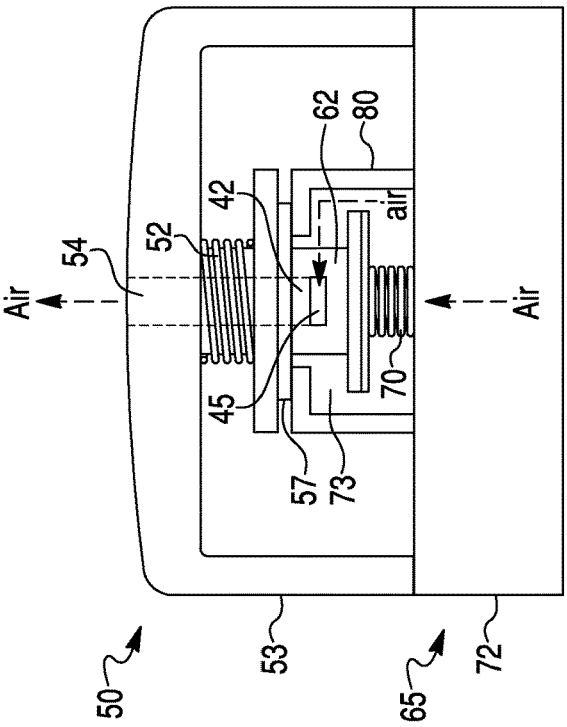


Fig. 5B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air
45
70
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Air
50
53
65
72

Fig. 5A

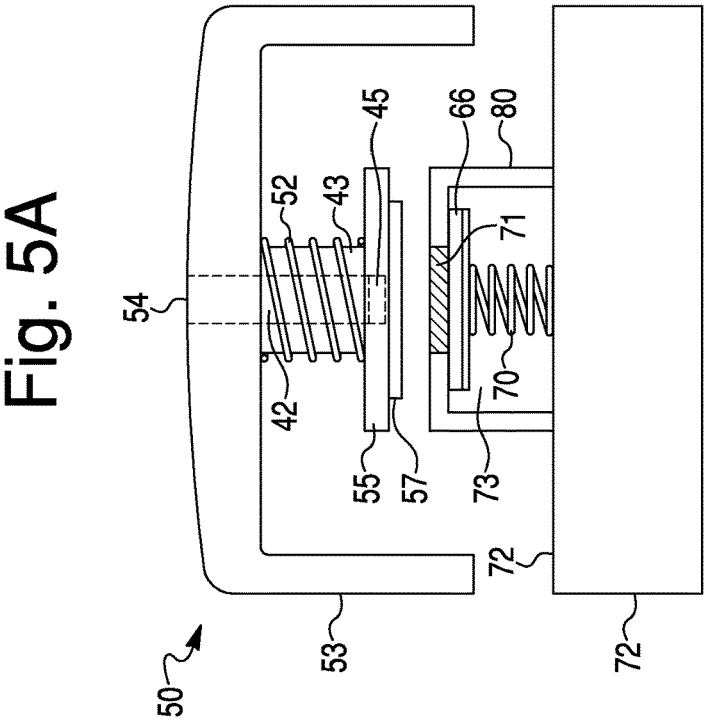
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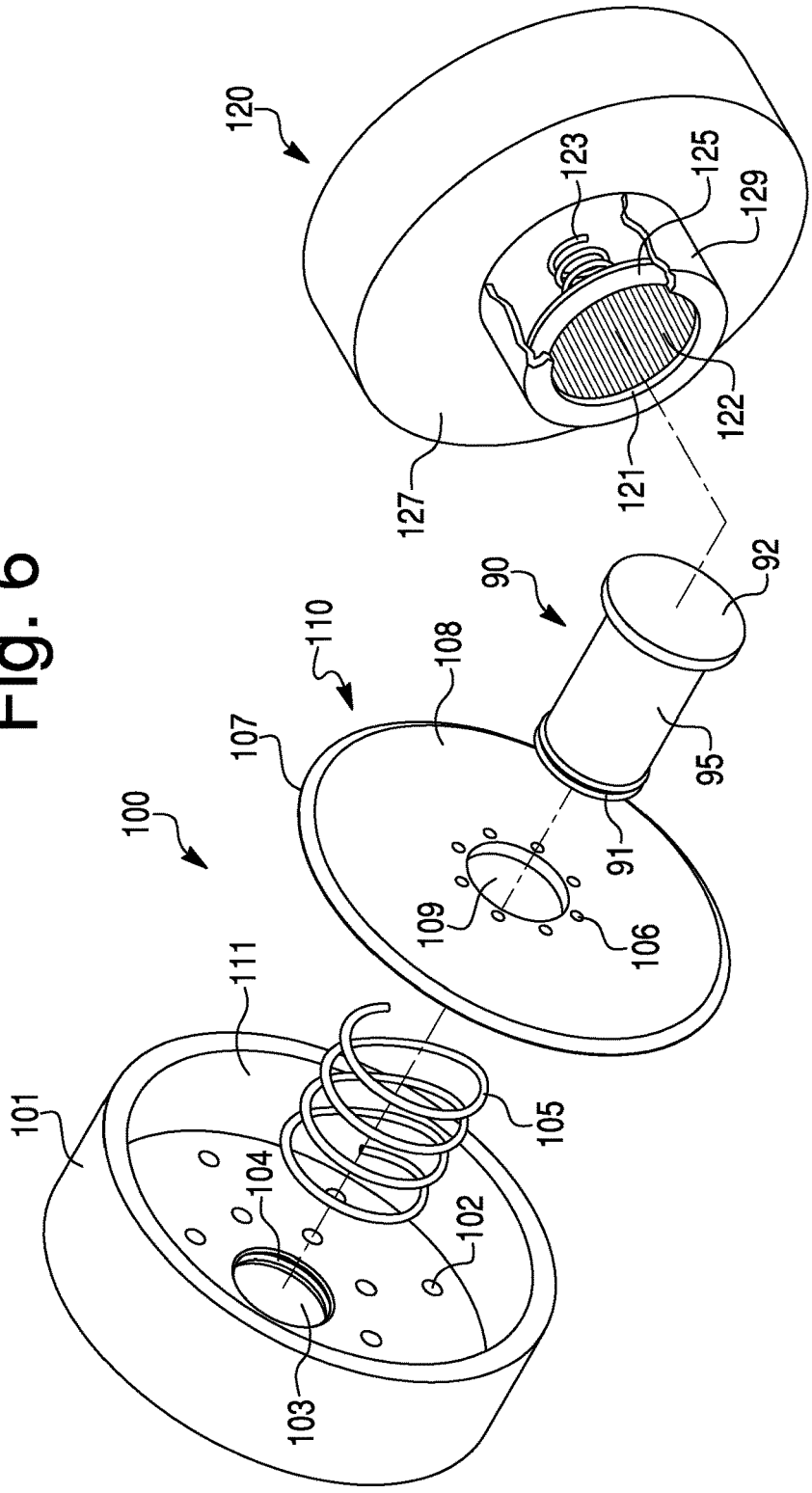
Fig. 6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129
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127
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110
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107
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100
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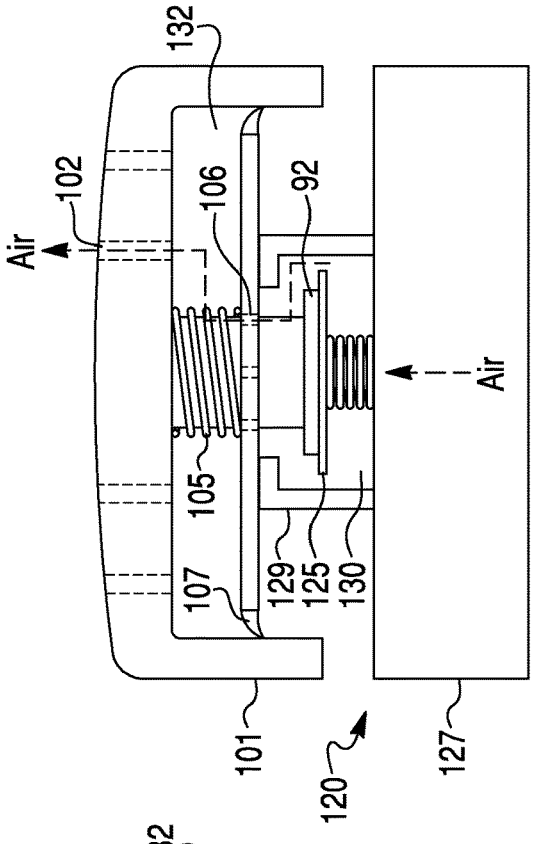
104
102
103

Fig. 7B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107
129
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130
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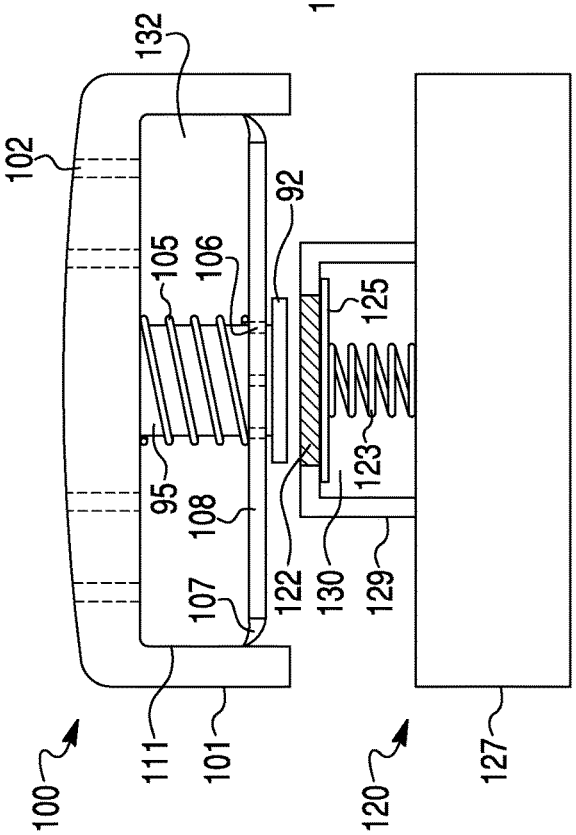
120
127

Fig. 7A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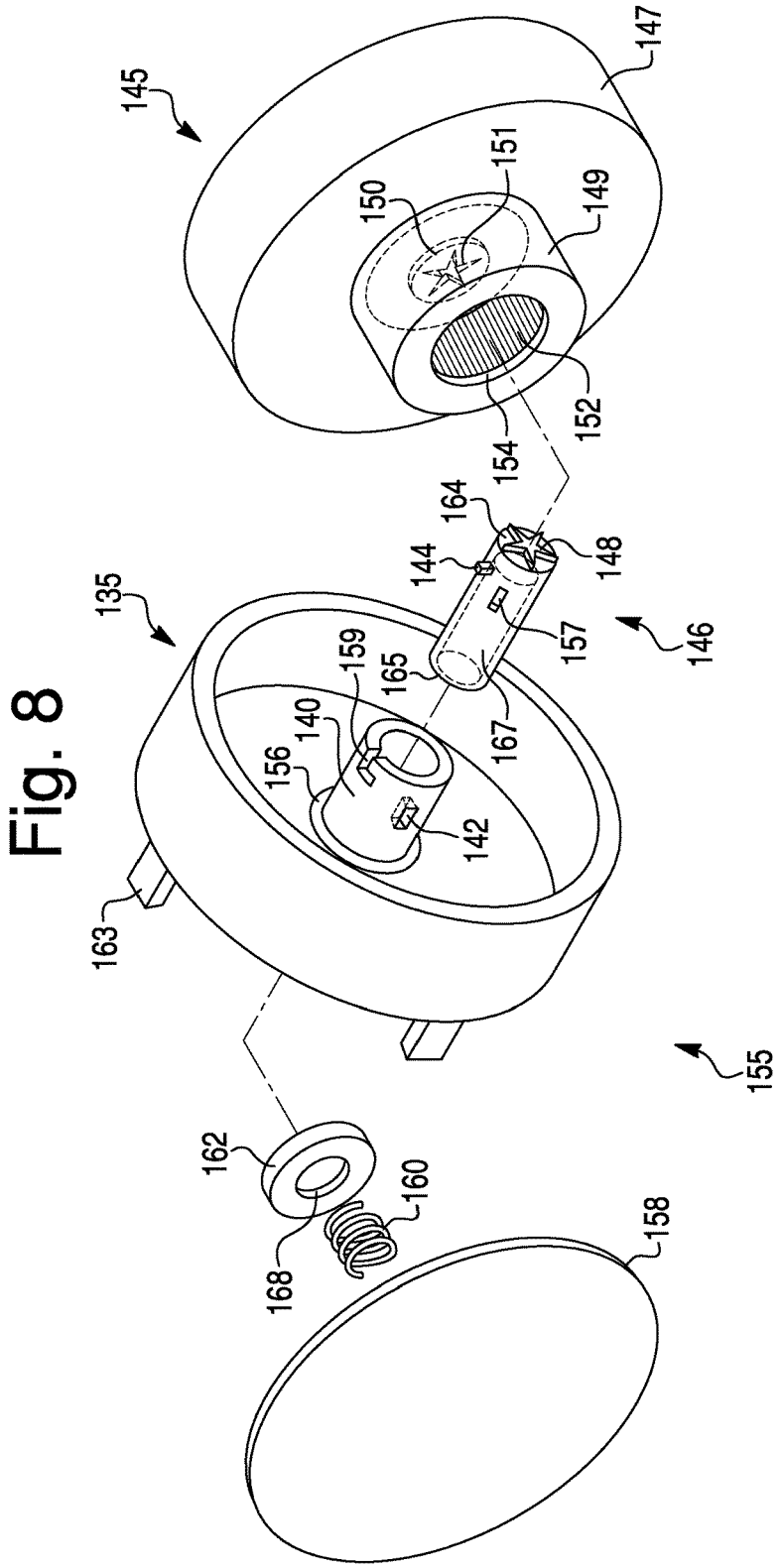
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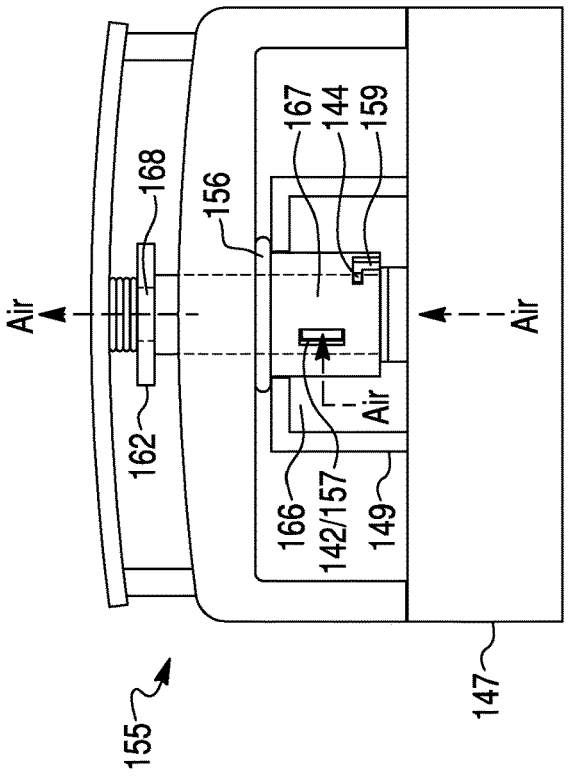
Fig. 8

Fig. 9B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144
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155
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Fig. 9A

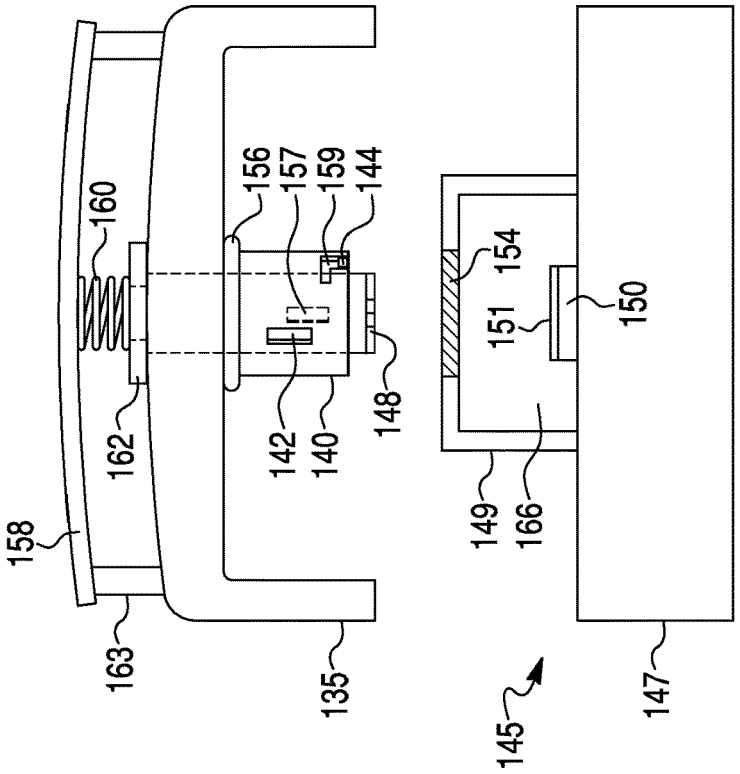
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Fig. 10

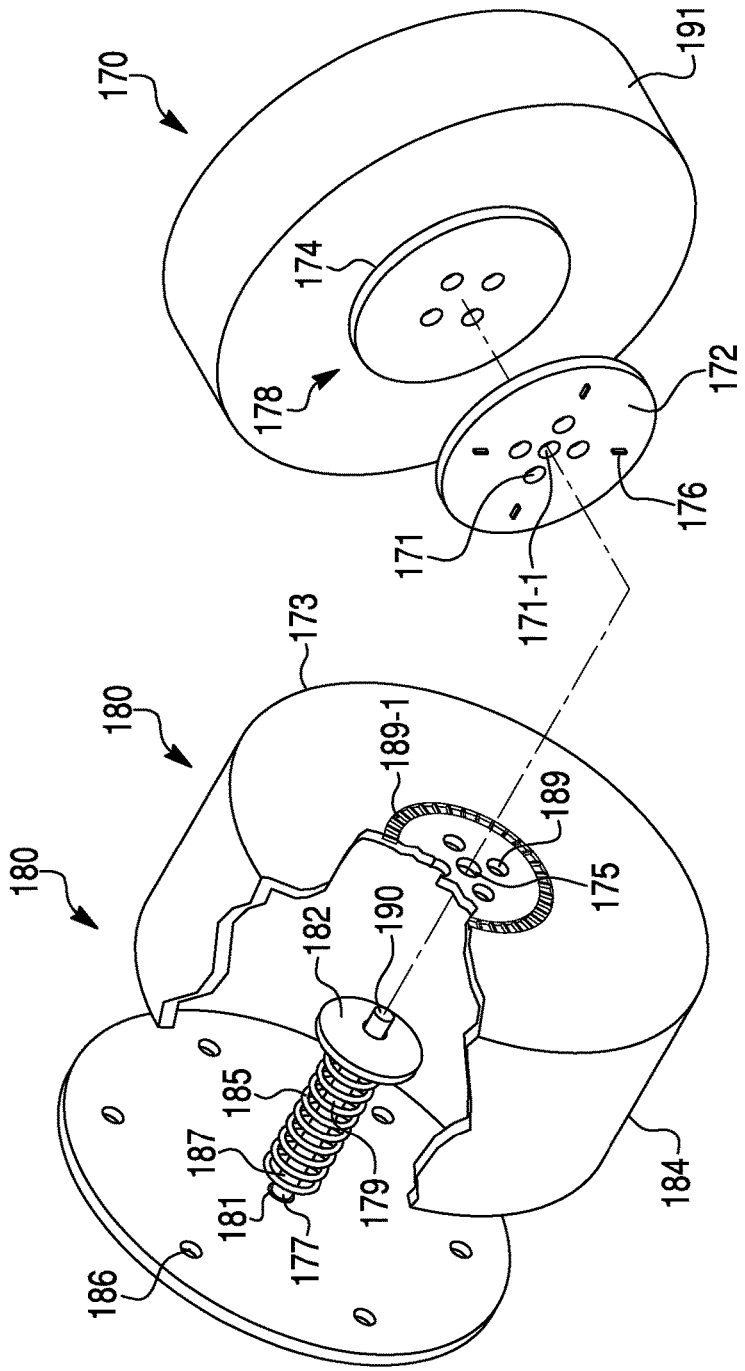
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Fig. 11B

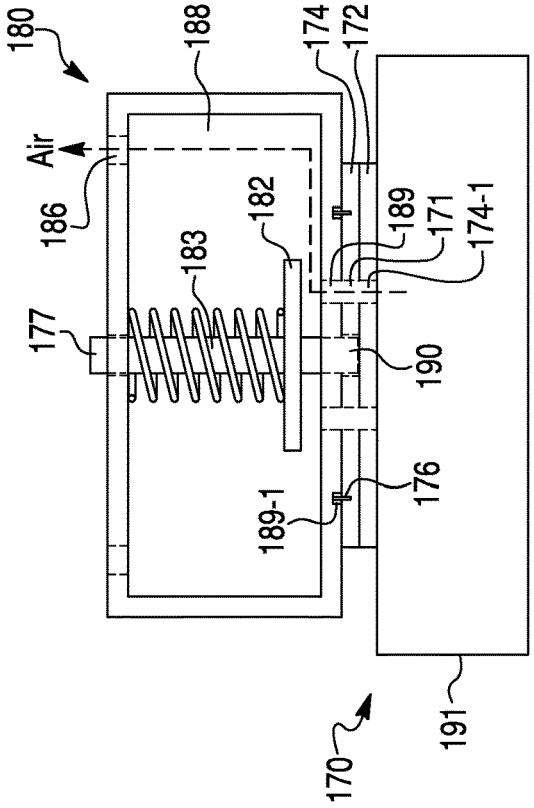

Fig. 11A

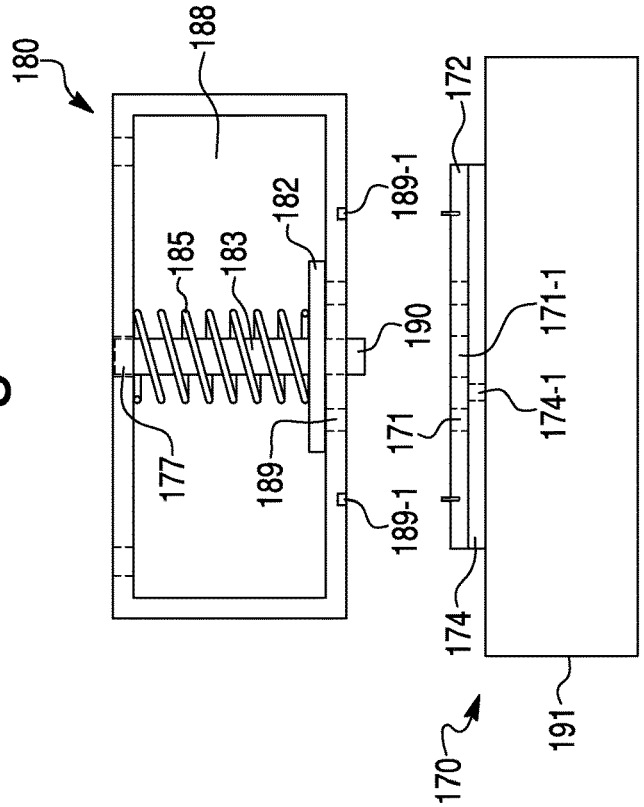

Fig. 12

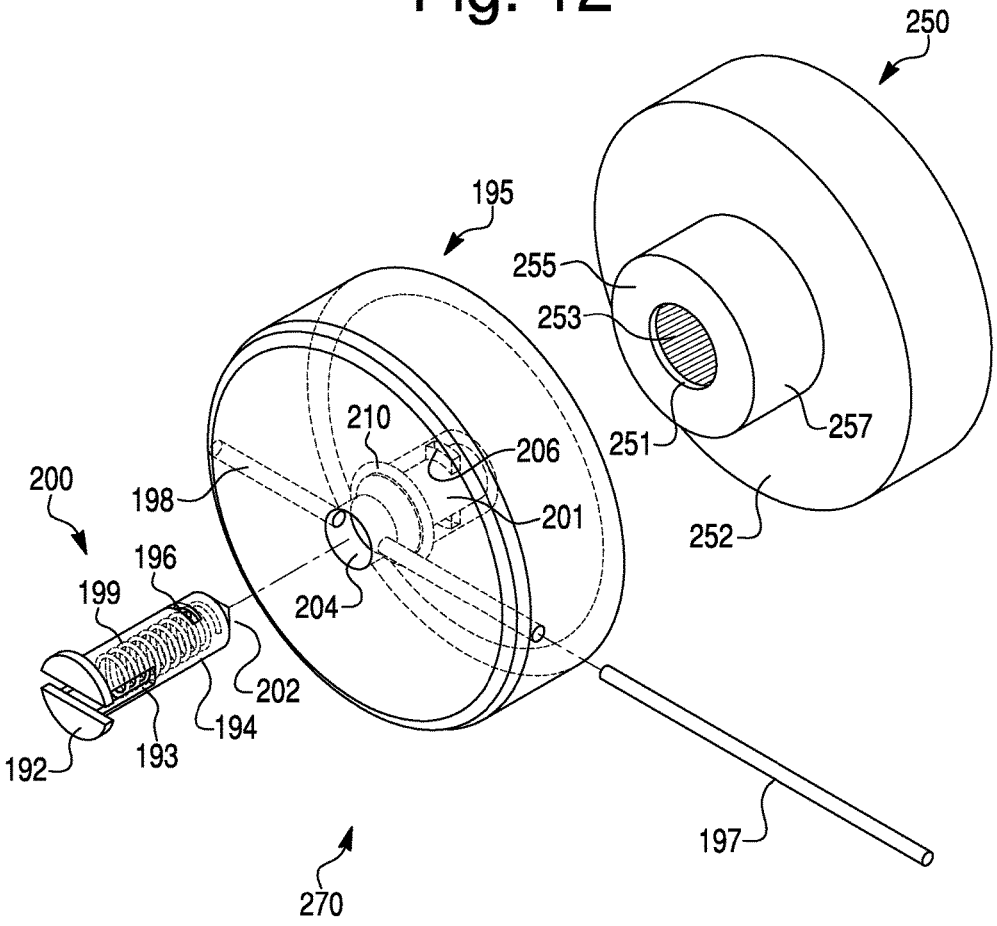
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Fig. 13B

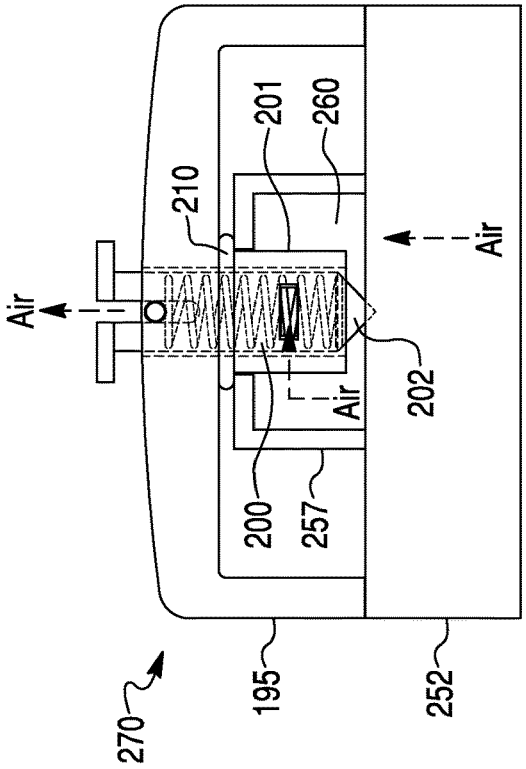


Fig. 13A

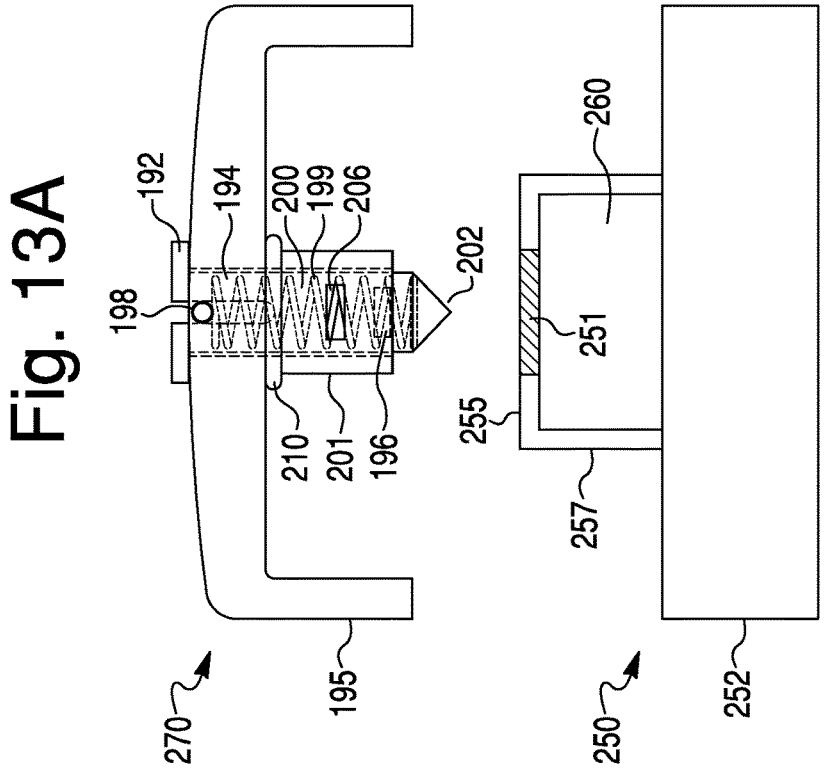


Fig. 14A

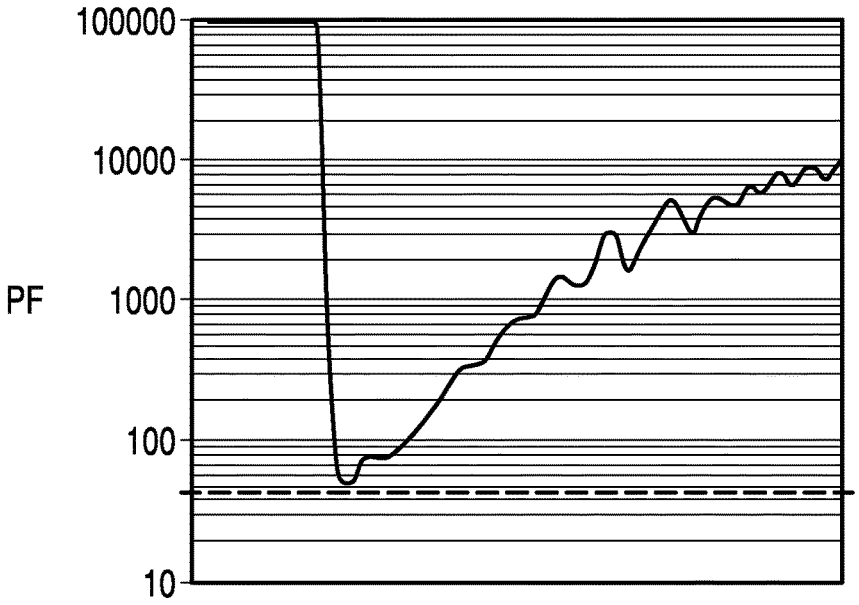
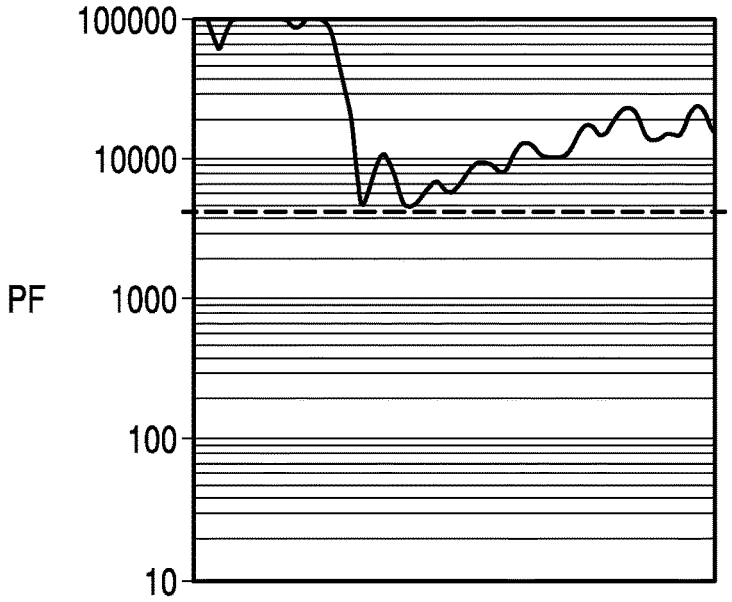


Fig. 14B



VALVE/CONNECTION SYSTEM TO PREVENT DOWNSTREAM CONTAMINATION FROM AN UPSTREAM SOURCE WHILE REPLACING FILTERS

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/900,699 filed on Nov. 6, 2013, the content of which is incorporated by reference in its entirety.

GOVERNMENT INTEREST

The invention described herein may be manufactured, used, and/or licensed by or for the United States Government.

FIELD OF THE INVENTION

This invention relates to an improved filter connection system for a respirator or gas mask to prevent contamination from an upstream source.

BACKGROUND OF THE INVENTION

Respirators are commonly worn over the breathing passages of a person to prevent impurities or contaminants from entering the wearer's respiratory tract.

A variety of respirators have been designed to meet this purpose. Some military respirators have been categorized as Joint Service General Purpose Masks ("JSGPM's"), for which filters will need to be periodically replaced to remain useful.

The effectiveness of JSGPM has been evaluated by comparing the amount of corn oil aerosol in a test chamber to that inside the mask while the test subject performs various exercises designed to stress the seal of the mask while wearing the mask in the chamber. Higher protection factor values assigned to the mask indicate that the user is getting a good seal and there is little or no contamination inside the mask.

Some of these aerosol tests were conducted as filter exchange tests to ensure that a user can switch out filters in a contaminated environment. During these trials, a user removes a filter on one side of the mask, relaxes for one minute to ensure that a seal is maintained, and then replaces the filter. The test results are evaluated on whether the protection factor value during the filter removal exercise goes below a certain threshold. The JSGPM performs well in this regard. However, when the filter is replaced on the mask, the contamination that is trapped in the cavities between the JSGPM filter mount and the filter canister itself can be pushed up into the mask by air pressure. This air movement reduces the Protection Factor of the mask from anywhere between 50-100 PF, which indicates that for several seconds the user is breathing a large amount of contamination from outside of the mask. While it is not hazardous to breathe in corn oil during a filter replacement test, in a real contaminated environment such a contamination spike would be enough to incapacitate or even kill a user based on the chemical or biological agent that was inhaled. This concern deters an individual user in the field from replacing filters in a contaminated environment, and users must exit the area of contamination to replace fitters and then re-enter the contaminated location to continue the mission, which greatly reduces the mission effectiveness.

A new filter connection system is being provided herein to address this issue. Various designs of the filter connection system will focus on removing the air cavities between the filter mount and filter canister, so that when users replace a filter while wearing a mask in a contaminated environment, the spike of contamination can be eliminated or greatly reduced.

SUMMARY OF THE INVENTION

The present invention provides an improved filter connection system for a gas mask, comprising a filter, a mounting means that attaches the filter to the gas mask, and a retainer means to hold the filter within the mounting means, the mounting means comprising: 1) a protruding means; 2) a valving assembly in communication with the protruding means, wherein the valving assembly enables air to flow from the filter to the gas mask when the retainer means retains the protruding means, and disables the air flow when the protruding means disengages from the retainer means; and 3) a sealing means located within or adjacent to the valving assembly to prevent air from outside of the filter entering the mounting means. The filter connection system allows minimal trapped air to exist in the mounting means during the replacement of the filter, so as to reduce the amount of contaminated air retained and breathed into the mask by the user during the filter replacement process. This filter connection system allows the user to replace the used filter in a field or contaminated environment.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with the other objects, features, aspects and advantages thereof will be more clearly understood from the following in conjunction with the accompanying drawings.

FIG. **1** depicts a filter mounted onto a gas mask.

FIG. **2** depicts an exploded view of the assembled filter connection system.

FIG. **3**A depicts a cross-sectional view of the filter connection system in an idle-state.

FIG. **3**B depicts a cross-sectional view of the filter connection system in an engaged state.

FIG. **4** depicts an alternative view of the assembled filter connection system.

FIG. **5**A depicts a cross-sectional view of the filter connection system in an idle-state.

FIG. **5**B depicts a cross-sectional view of the filter connection system in an engaged state.

FIG. **6** depicts an alternative view of the assembled filter connection system.

FIG. **7**A depicts a cross-sectional view of the filter connection system in an idle-state.

FIG. **7**B depicts a cross-sectional view of the filter connection system in an engaged state.

FIG. **8** depicts an alternative view of the assembled filter connection system.

FIG. **9**A depicts a cross-sectional view of the filter connection system in an idle-state.

FIG. **9**B depicts a cross-sectional view of the filter connection system in an engaged state.

FIG. **10** depicts an alternative view of the assembled filter connection system.

FIG. **11**A depicts a cross-sectional view of the filter connection system in an idle-state.

FIG. **11**B depicts a cross-sectional view of the filter connection system in an engaged state.

FIG. **12** depicts an alternative view of the assembled filter connection system.

FIG. **13**A depicts a cross-sectional view of the filter connection system in an idle-state.

FIG. **13**B depicts a cross-sectional view of the filter connection system in an engaged state.

FIG. **14**A depicts leak test results from a conventional filter connection system.

FIG. **14**B depicts leak test results from an improved filter connection system.

DETAILED DESCRIPTION

The present invention provides an improved filter connection system for a gas mask, such that when the filter is being replaced or installed, the trapped air within the filter mount and the filter is minimized or eliminated, to prevent any contaminants carried within the trapped air to be pushed into the gas mask by air pressure.

The present invention provides an improved filter connection system for a gas mask, comprising a filter, a mounting means that attaches the filter to the gas mask, and a retainer means to hold the filter within the mounting means, the mounting means comprising: 1) a protruding means; 2) a valving assembly in communication with the protruding means, wherein the valving assembly enables air to flow from the filter to the gas mask when the retainer means retains the protruding means, and disables the air flow when the protruding means disengages from the filter means; and 3) a sealing means located within or adjacent to the valving assembly to prevent air from outside of the filter entering the mounting means. The filter retainer means further includes an opening to fully and tightly receive the protruding means, such that the retainer means engages and shifts the protruding means to trigger the valving assembly to enable air to flow from the filter, through the mounting means to the breathing path within the gas mask. A membrane or film seals the opening, so to ensure that no contaminant enters the filter, prior to the retaining means receiving the protruding means. The sealing means insulates the air flow path and prevents contaminated air from being drawn into the filter connection system. When a user replaces the filter, the user disengages the filter connection system from the mounting means. The replacement releases the protruding means from the retainer opening, such that the valving assembly encloses and secures the protruding means to seal off the air flow path, preventing the user from breathing in contaminated air.

The filter is selected from the materials consisting of high efficiency particulate air ("HEPA") filters, activated carbon filters, pleated paper-type filters, and mixtures thereof.

Several embodiments of the filter connection system are shown. Generally, each filter connection system **300** is fitted onto either side of the gas mask **350** as shown in FIG. **1**. In FIG. **2**, a filter connection system comprises a filter **40**, a mounting means **10** that attaches filter **40** to a gas mask, and a retainer means **38**, which holds the filter **40** to mounting means **10**. Mounting means **10** is comprised of a protruding means **1**, and a valving assembly that is comprised of a back plate **15**, a tension means **12**, and a cover **16** that further includes supports **23** and a tubing **22** that has an inlet **17**. Briefly, tension means **12** is located at the center of back plate **15** and attached to an end **6** of protruding means **1** and anchors protruding means **1** within tubing **22** of cover **16**, such that inlet **17** is linearly located between an inlet **5** and an outlet **7** of protruding means **1**. Supports **23** connect and secure back plate **15** onto cover **16**, such that the valving assembly encloses protruding means **1** to form mounting means **10**.

As shown in FIG. **3**A, in an "idle-state", inlet **17** is not aligned with outlet **5**, thus, inlet **5** and outlet **7** are closed to block off air from outside of mounting means **10**, while retainer means **38** connects to filter **40**, and has an opening **24** that is blocked by membrane **35**, so that no air flows into filter **40**. The assembly of filter **40** and retainer means **38** is a filter means **30**.

As shown in FIG. **3**B, in an "engaged state", placement of a new filtering means **30** onto mounting means **10** causes a tip **3** of protruding means **1** to puncture through filter membrane **35** located within opening **24** of retainer means **38**, such that tubing **22** fits tightly through opening **24**. Cover **16** closes onto filter surface **37**, and a sealing means **20** seals the gap between mounting means **10** and a platform **39** of retainer means **38**. At this point, filter **40** stops and pushes tip **3** upward, thereby shifting protruding means **1** to align inlet **17** with inlet **5** and to open outlet **7**, so that air flows from filter **40** into a compartment **36** and inlet **17**, through a tubing **9** of protruding means **1** and exits outlet **7** into the breathing path of the mask.

Since there is no outside air present from the time tip **3** of protruding means **1** punctures through membrane **35**, and since opening **24** is only slightly larger than tubing **22**, there is minimal if any contamination that enters into the mask. Further, sealing means **20** is the primary seal between mounting means **10** and filter means **30** in an engaged state. The air flow will create a negative air pressure gradient with filter means **30**. Mounting means **10** with cover **16** will provide a good seal to prevent contamination from entering the space.

Alternatively, another embodiment is shown in FIG. **4**, wherein a mounting means **50** includes a protruding means **41**, and a valving assembly that is comprised of a cover **53**, a tension means **52**, an opening **54**, a disk **55**, and a sealing means **57**. Briefly, protruding means **41** fits through disk **55** and sealing means **57**, such that disk **55** is adjacent and above sealing means **57**, and sealing means **57** is adjacent and above end **62**. Tension means **52** encloses protruding means **41** exposing a threaded end **64** that matches and attaches to a threaded opening **63** of cover **53**, to establish an open channel from tubing **42** of protruding means **41** to opening **54**.

As shown in FIG. **5**A, in an "idle-state", disk **55** blocks inlet **45** to seal off any air flow from outside of mounting means **50**. A filter **72** is attached to a retainer means **80** to form a filter means **65**, and has an opening **68** that is covered by a membrane **71**. A tension means **70** within retainer **80** pushes up a platform **66**, such that platform **66** is underneath membrane **71** and flushed against opening **68** to prevent contaminated air from entering filtering means **65**.

As shown in FIG. **5**B, in an "engaged state", placement of filtering means **65** causes a base **62** of protruding means **41** to break through membrane **71**, and to push down platform **66** located within retainer means **80**, which is adjacent and above filter **72**. At this point, cover **53** of the mounting means **50** comes in direct contact with filter **72**, compresses tension means **52** and **70**, such that inlet **45** is exposed to a compartment **73** within retainer **80**, so that air flows from filter base **72** into compartment **73** and inlet **45**, through tubing **42** of protruding means **41** and exits out opening **54** into breathing path of the mask. Sealing means **57**, in the

form of an o-ring, seals the gap between mounting means **50** and retainer means **80** to prevent contaminated air from entering.

Alternatively, another embodiment of the filter connection system is shown in FIG. **6**, wherein the filter connection system comprises a mounting means **100** that includes a solid protruding means **90**, and a valving system that includes a cover **101** that has an opening **103**, an air holes **102**, a tension means **105**, and a disk **110** comprises a sealing means **107** on its outer circumference, a central opening **109** and air holes **106** surround opening **109**.

As shown in FIGS. **6** and **7**A, in an "idle-state", a column **95** of protruding means **90** fits through central opening **109**, wraps by tension means **105** and anchors to opening **103** through a threaded end **91** that engages threads **104** of cover **101**. Accordingly, the valving system encloses protruding means **90** to form mounting means **100**. Further, a base **92** of protruding means **90** in the form of a gasket, is wide enough to cover air holes **106**, and sealing means **107** is flushed against the inner wall **111** to cover **101**. At this point, base **92** and sealing means **107** effectively block air flow from outside of mounting means **100**. Meanwhile, a retainer means **129** contains an opening **121**, which is covered by a membrane **122**. Retainer means **129** further includes a tension means **123** that pushes up a platform **125**, to further block opening **68**, underneath membrane **122**, to prevent contaminated air from entering filter **127**. An assembly of retainer means **129** and filter **127** is a filtering means **120**.

As shown in FIG. **7**B, in an "engaged-state", placement of filtering means **120** causes base **92** of protruding means **90** to break through membrane **122** and to push down platform **125** of retainer means **129**, which is adjacent and above filter **127**. At this point, cover **101** of the mounting means **100** comes in direct contact with filter **127**, compresses tension means **105** and **123** and pushes down protruding means **90** into a compartment **130** to expose air holes **106**, such that air flows from filter base **127** into a compartment **130**, through air holes **106** into compartment **132** then exits air holes **102** into breathing path of the gas mask. Sealing means **107**, in the form of a rubber ring surrounding disk **110**, seals the gap between mounting means **100** and retainer means **129** to prevent contaminated air from entering.

Alternatively, another embodiment of the filter connection system is shown in FIG. **8**, wherein the filter connection system comprises a mounting means **155**, 1) a hollow protruding means **146** that includes inlet **157**, a knob **144**, and a male portion **168** on one end **164**; and 2) a valving system that includes a back plate **158**, a tension means **160**, an anchor disk **162**, and a cover **135** that further includes a tubing **140** with an inlet **142** and an anchoring groove **159**.

As shown in FIG. **8** and FIG. **9**A, in an "idle-state", an end **165** of protruding means **90** is engaged to anchor disk **162** and attached through threaded opening **168**, which is attached to tension means **160**. Back plate **158** pushes down tension means **160**. A second end **164** of protruding means **146** then fits through tubing **140**, and cover **135** is twisted such that knob **144** on protruding means **146** slide onto anchoring groove **159**, and inlet **157** is parallel to inlet **142**, but blocked by the tubing wall of **140**. At this point, back plate **158** is attached to cover **135** via stands **163** and holds tension means **160** in place to provide tension/pressure onto anchor disk **162**. Overall, the valving system encloses protruding means **146** to form mounting means **155**. Meanwhile, filtering means **145** is comprised of a filter **147** and a retainer means **149** that includes an opening **154** that is covered by a membrane **152**, which prevents contaminated air from entering filter means **145**. Within the retainer means there is a matching platform **150** containing a female pattern **151** that matches with male pattern **148** of protruding means **146**.

As shown in FIG. **9**B, in an "engaged-state", placement of filtering means **145** causes protruding means **146** to break through membrane **152**, and male part **148** matches female part **151**. The matching anchors protruding means **146** to filter **147**. Sealing means **156** seals the gap between retainer means **149** and mounting means **155**. Thereafter, filter **147** is twisted to shift knobs **144** deeper into and anchors by anchoring groove **159**, causing inlets **157** and **142** to align, such that air flows from filter **147** into a compartment **166**, entering inlets **142** and **157** into tubing **167** and exits opening **168** on disk **162** into breathing path of the gas mask.

Another embodiment of the filter connection system is shown in FIGS. **10** and **11**A, wherein the filter connection system comprises 1) a filter means **170** that includes a filter **191** and a retainer means **178** having a disk **172** and **174**; and 2) a mounting means **180**, wherein mounting means **180** is comprised of a protruding means **179** enclosed within a valving system that includes a tension means **185**, a sealing means **182**, a housing **184**, and a cover **173** that has a center hole **175**, inlets **189** surrounding hole **175** and track **189-1** surrounding the inlets **189**. In an "idle-state", a tension means **185** wraps a column **187** of protruding means **179**, exposing an end **177**, which then fits through an exit hole **181** of housing **184**, and the other end **190** of protruding means **179** fits through sealing means **182** and holding hole **175** centrally located in cover **173**. Cover **173** then closes onto housing **184**, exposing ends **177** and **190** to form mounting means **180**. Sealing means **182**, in the form of a washer gasket, securely covers inlets **189** to block contaminated air from entering mounting means **180**. Meanwhile, retainer means **178**, including disk **172** that has bulges **176** latchable to track **189-1**, and is adjacent and rotatable relative to disk **174**, wherein disk **172** has holes **171** surrounding anchoring hole **171-1**, and disk **174** has holes **174-1** that matches holes **171** when disks **172** and **174** are in "open" positions. In idle-state, the disks **172** and **174** are in a "lock" position, so that disk **174** covers holes **171** on disk **172**, to block contaminated air from entering filtering means **170**.

As shown in FIG. **11**B, in an "engaged state", placement of filtering means **170** onto mounting means **180** causes end **190** of protruding means **179** to fit tightly into anchoring hole **171-1**, through disk **172** but stops at disk **174**, such that bulges **176** latch onto track **189-1** and disk **174** pushes end **190** upward, lifting up sealing means **182** to reveal inlets **189**, which are now aligned with holes **171**. Filter means **170** is then twisted to rotate disk **172**, such that holes **171**, **189** and **174-1** are all aligned to allow air flow from filtering **191** into a compartment **188** and exits out holes **186** into breathing path of the gas mask.

Another embodiment of the filter connection system is shown in FIGS. **12** and **13**A, comprising 1) a filter means **250** that includes a retainer means **257** and a filter base **252**; and 2) a mounting means **270** that is comprised of a hollow protruding means **200** enclosed within a valving system that includes a tension means **199**, a rod **197** and a cover **195**. In an "idle-state", protruding means **200** contains tension means **199** and is inserted into an opening **204** of cover **195**, then settles into a tubing **201**, leaving a top **192** exposed above cover **195**, and a tip **202** exposed outside of tubing **201**, opposite to top **192**. At this point, a groove **193** of protruding means **200** aligns with a channel **198** in cover **195**, and rod **197** inserts into channel **198** through groove **193**, such that rod **197** is adjacent and above tension means

199 to enclose protruding means 200 within cover 195 to form mounting means 270. At this point, an inlet 196 of protruding means 200 is parallel and below an inlet 206 of tubing 201, such that the tubing wall of 201 blocks inlet 196 to prevent contaminated air from entering mounting means 270. For filtering means 250, a membrane 253 covers an opening 251 of retainer means 252 to prevent contaminated air from entering filter 252.

As shown in FIG. 13B, in an "engaged state", placement of filtering means 250 onto mounting means 270 causes tip 202 to break through membrane 253, slides tubing 201 into compartment 260 and is stopped by filter 252. At this point, cover 195 is in contact with filter 252, and a sealing means 210 seals the gap between retainer 257 and cover 195 to prevent contaminated air from entering the filter connection system. As filter 252 stops tip 202 from advancing further, protruding means 200 is being pushed backwards within tubing 201 in the direction of rod 197, such that tension means 199 is compressed to align inlet 196 with inlet 206, so that air flows from filter 252 into compartment 260, through the aligned inlets, and exits from inner tubing 194 of protruding means 200 into breathing path of the gas mask.

EXAMPLE

A comparative test was conducted on an existing connection system on JSGPM versus an improved filter connection system. Corn oil aerosol was sprayed in a test chamber and a user in the chamber removes a filter from one side of the gas mask, releases for one minute to ensure that a seal is maintained, and then replaces the filter. A measurement of the leak proof aspect was done in Protection Factor when the filter is replaced on the mask. As shown in FIG. 14A, contamination spiked when the existing connection system was used and its corresponding filter was replaced in a tested environment, wherein the Protection Factor dropped to 50 PF from about 100,000 PF, or about 2.00% leak penetration, meaning that for several seconds, the users was breathing a large amount of contaminants from outside of the mask. Meanwhile, for the improved filter connection as shown in FIG. 14B, the Protection Factor only dropped to 4,000 PF from 100,000 PF, or about 0.025% leak protection, a drastic reduction from the existing connection system and an improvement which enables a user to change gas mask filters while in a contaminated field environment.

The invention claimed is:

1. A filter connection system, comprising: a filter, a mounting means that attaches said filter to a gas mask, and a retainer means to hold said filter within said mounting means, said mounting means including protruding means and a valving assembly in communication with said protruding means, wherein when said protruding means engages said retainer means said valving assembly enables air to flow from said filter to said gas mask, and disables air flow from said filter to said gas mask when said protruding means is disengaged from said retainer means, and wherein no outside air is entrapped between said protruding means and said retainer means when said protruding means engages said retainer means and said valving assembly enables air to flow from said filter to said gas mask; wherein said retainer means further includes an opening that receives said valving system, protruding means or both; wherein said opening contains a membrane that blocks air from entering said filter, and said protruding means breaks said membrane upon engaging said retainer means.

2. The filter connection system of claim 1, wherein said mounting means further includes a sealing means located within or adjacent to said valving assembly to provide an airtight seal between said mounting means and said retainer means.

3. The filter connection system of claim 2, wherein said sealing means is in the form of a gasket material made from a material selected from butyl or nitrile rubber.

4. The filter connection system of claim 1, wherein said protruding means is hollow and contains at least one inlet that upon engaging said retainer means allows air to flow from said filter into said valving assembly.

5. The filter connection system of claim 1, wherein said valving assembly includes a tension means that anchors the protruding means within said valving assembly prior to said protruding means engaging said retaining means, and after said engaging said tension means compresses to allow said protruding means to shift within said valving assembly to enable air to flow from said filter to said mounting means.

6. The filter connection system of claim 1, wherein said retainer means further includes a platform, wherein said platform blocks said opening prior to said protruding means engaging said retainer means, and said protruding means pushes down said platform to expose air from said filter base to said protruding means.

7. The filter connection system of claim 1, wherein said retainer means has a female portion, and said protruding means contains a male portion, wherein said female and male portions match to connect and anchor said protruding means within said retainer means.

8. A gas mask including a filter connection system of claim 1, wherein said mounting means is attached to said gas mask, wherein said retainer means holds said filter to said mounting means, wherein said protruding means engages said retainer means and shifts within said valving assembly to enable air to flow from said filter to said gas mask, and upon said retainer means releasing said filter from said protruding means, said mounting means is sealed from air flow.

9. The filter connection system of claim 1, wherein said valving assembly includes a cover that contains at least one inlet that upon engaging said retainer means, allows air to flow from said filter into said valving assembly.

10. The filter connection system of claim 9, wherein said retainer means contains a series of vents that match inlets on said cover to said valving assembly, such that when said protruding means engages said retainer means, air flows from said filter base through said vents and said inlets into said mounting means.

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